John Dalton, F.R.S

THE WORTHIES OF CUMBERLAND.

JOHN DALTON, F.R.S.

Member of the French Institute;
Hon. D.C.L. Oxon.; LL.D. Edin.;
President of the Literary and Philosophical Society of Manchester,
&c. &c.

BY

HENRY LONSDALE, M.D.

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To

HENRY E. ROSCOE, B.A.,

Ph.D., F.R.S.

Professor of Chemistry in Owens' College, Manchester;

This Memoir

is inscribed,

with the sincere good wishes of his Friend

THE AUTHOR.

PREFACE.

THE centenary of Dr John Dalton's birth was commemorated at Carlisle on September 5, 1866, by a public dinner, at which gentlemen from all parts of the country assembled. The proceedings of the meeting were reported in the *Manchester Guardian* and *Carlisle Journal*. In the absence of one more worthy of the post, I occupied the chair, and was further honoured by a request to enlarge my extempore biographical sketch of Dalton, and to publish it as a brief memoir. More mature consideration showed that the history of the Founder of the Atomic Theory could not be embraced in less than a volume; and that it would be well to wait the issue of the Lives of John Christian Curwen, William Blamire, and Sir James Graham, the first of the series of "Cumberland Worthies." The delay that has arisen since that period has not been owing to any lukewarmness on my part in the cause

of science, but rather to my being too deeply engaged in the historical department of the Biological Sciences, of which some proof is afforded in my Biographies of Professor Goodsir and Dr Robert Knox, the highly distinguished Scottish anatomists.

As one of the promoters of the Cavendish Society, London, I was glad the Society entrusted the Life of Dr Dalton to his able pupil and literary executor, Dr William Charles Henry, F.R.S., than whom no one was better fitted for the task. Seven years previous to the issue of Dr Henry's valuable Memoir, I had commenced inquiries regarding Dalton's family relations and his earlier years; and owing to my pleasant intimacy with the leading members of the "Society of Friends" in Cumberland, every facility was afforded me for obtaining information regarding his personal history and character. The centenary had passed, and my plan of this Memoir sketched out, before I was aware, through the kindness of my estimable friend Mr Edmund Potter, F.R.S., formerly M.P. for Carlisle, of the excellent Life of Dalton, written by Dr Robert Angus Smith for the Literary and Philosophical Society of Manchester. Both these Biographies are admirable and conclusive as to Dr Dalton's original work and grand services to chemistry. No one can follow these faithful historians

without deriving advantage, and here I beg gratefully to acknowledge my indebtedness to them both. They wrote for the scientific public; my effort is a much humbler one, aiming more or less to satisfy the wants of a quasi-popular or less instructed class of readers. The science that Dalton taught has not, however, been lightly passed over in the following pages, but rather epitomised and offered, as far as circumstances permit, in a form comprehensive to all persons of average intelligence.

Favoured by a number of letters of Dalton's, and much original information hitherto unpublished, I am enabled to present my readers with a more correct personal history of the famous chemical philosopher than has yet appeared in print.

Among those with whom I had repeated conversations on Dalton's history may be mentioned my late worthy friends Jonathan and Jane Carr of Carlisle, who were pupils of the Daltons at Kendal, and had a lively recollection of the junior schoolmaster; my charming and joyous-hearted friend Mary Sutton, who thoroughly appreciated the chemical philosopher; and the estimable Mr John Wilson Fletcher of Tarn Bank, near Cockermouth, with whom Dalton invariably spent an evening on all his visits to Cumberland. Many more, especially members of the Society of

Friends, who aided me, have passed the bourne that allows of no grateful recognition. Others, happily, live, to whom I can offer my cordial thanks—namely, my constant friends Isaac Fletcher, M.P., F.R.S., and William Fletcher, Esq. of Brigham Hill, for valuable documents; Henry A. Fletcher, Esq. of Lowca Works; Wm. B. Clarke, Esq. of Barwickstead; and Edward Waugh, Esq. of Cockermouth, for aiding me in my inquiries: to my dear friend Mrs Henry Wigham of Dublin I am indebted for Dalton's correspondence with Elihu Robinson; whilst the letters that passed between Dalton and Joseph Dickinson on colour-blindness came from the valuable repertory of Cumbrian literature of my friend Mr William Jackson of Fleatham House, St Bees.

I was greatly helped in my inquiries at Manchester by my esteemed friend Professor Roscoe, and to Mr G. S. Woolley I am indebted for a perusal of his father's essay, and Dalton's correspondence with the Johns family.

In looking over the history of the Atomic Theory and the opinions of authors, among whom Professor Daubeny stands foremost, I cannot help recalling the eloquent mode in which my Edinburgh associate, and truly a man of genius, Dr Samuel Brown, treated this subject in a series of lectures, which were, after his

death, published in two 8vo volumes by Thomas Constable & Co., under the title "Lectures on the Atomic Theory, and Essays Scientific and Literary, by Samuel Brown."

The portrait of Dalton in the frontispiece, and described in page 225 of this Memoir, has been faithfully lithographed by Vincent Brooks, Day, and Son, London. The autograph beneath the portrait was copied from a certificate of Dalton's, written about his sixty-third year.

ROSE HILL, CARLISLE.
July 20, 1874.

CONTENTS.

APPENDIX.

ERRATUM.

Page 32, 13th line, *for* "Sep. 6," *read* "Sep. 5."

JOHN DALTON.

INTRODUCTORY CHAPTER.

"*Now the true and genuine end of the sciences is no other than to enrich human life with new inventions and new powers. . . . Fruits and discoveries of works are as the vouchers and securities for the truth of philosophies.*"—LORD BACON.

"LIGHT, more light!" was the last utterance of Goethe the poet, playwright, and philosopher. Emanating with the lightning before death, these words were looked upon by the friends and disciples of the renowned German, as the breathings of the oracular spirit, or "primitive divination," that Lord Bacon assigned to men of philosophic genius in the hour of their departure for the unknown bourne. More light is the chief desideratum in the world of thought, as it is the guide and aim of all who strive after the good, the beautiful, and the useful; but of the multitude of workers so disposed, how incomparably few can expect to realise the height attained by Goethe, a great master in art, the founder of German literature, and early promoter of transcendental anatomy.

Light traverses space with measured yet almost inconceivable rapidity, and reveals countless orbs and a countless time; but the light of ideas, brought to bear upon the interpretation of nature, is but gradatory and fitful in its manifestations, and ever dependent on the happy genesis or moulding of a human being endowed with "the vision and the faculty divine." When this psychological light comes vividly forth in such instances as Da Vinci, Galileo, Harvey, and Newton, it gives rise to new and nobler developments of human thought, and furnishes permanent landmarks in the historical path of science and philosophy.

As chemistry treats of the nature and composition of bodies, its study might have been held of paramount value and attractiveness, as furthering the interests of man in all his advances to material enjoyment and civilisation. Its interest, however, does not seem to have been commensurate with the attention bestowed upon the physical sciences, the laws of which were in part indicated by Ptolemy, and after a long halt by Copernicus, and subsequently so nobly interpreted by the labours of Galileo, Kepler, and Newton. Yet the crude arts of chemistry may be recognised as coeval with the earliest of all human inventions; indeed, every effort to rise above the essential wants of bodily sustenance, and even to aid in that primary step of life, would necessarily call forth the ingenuity of man, seeking to convert the organic growth and inorganic substances of the earth to the increasing of his resources, and the bettering of his physical condition.

Enraptured in belief, and not less prone to the wild-

est of superstitions, the nations of antiquity traced their origin to demigods, prophets, and heroes of the superhuman sort, and to make their pretensions to science consonant with the fabulous character of their history, gave large attention to those dark-age mysteries, astrology and alchemy. The former pursuit (astrology) evoked divination and protean prophecies; the latter (alchemy) dealt largely in mystic arts, from which, after the lapse of centuries, arose tangible data, constituting important accessories to a real science, that of chemistry itself.

A few words on the rise of alchemy, "the sacred and divine art of making gold and silver," may serve as an introduction to the modern science of chemistry, of which John Dalton became the Grand-Master in these latter days of European history. The origin of alchemy is involved in doubt, but the curious in such matters will find the genii of the East, as well as angels and women, credited with a part in the esoteric dogma, upon which probably more arts than that of alchemy were based. The prefix *al*, in alchemy, is clearly Arabian, possibly invented by the followers of the occult art, to distinguish the doctrine of transmutation from the *chemia* that embraced only simple chemical operations — in other words, that of vulgar chemistry as disjoined from "the divine art."

In all his attempts to unravel the web of history, man looks to the East for the growth and collateral bearings of his civilisation, and, in endeavouring to fathom the impenetrable problem of his own genesis, and the gradatory lines of his intellectual and moral development, is led to consider the arts, acquirements,

and erudition of the people who occupied the banks of the Nile many thousand years ago. In this (Nile) valley of sunny sky and pure ether—of lands rich in cereal and saccharine growth—man's physical wants were easily sustained, thereby affording him freer scope for the exercise of his understanding and the culture of his genius. No one possessing the opportunity of traversing the land of the Pharaohs can fail to observe that the Egyptians who lived in the palmy days of Luxor and Thebes—upwards of 3000 years before the Christian era—showed an acquaintance with the chemistry of the arts far beyond the general supposition of modern writers. The Egyptian separated metals from their ores, and practised the arts of metallurgy with manifest success; he quarried massive monoliths from the syenite of Assouan, and carved the finest lines on the hardest of granitic structures; he fabricated gold and silver, and jewelled ornaments to deck his person, already beautified by cosmetics and fragrant with essential oils; he wove his linen and woollen stuffs, then bleached and dyed them; and pursuing his chemical operations beyond our knowledge and discovery, adorned his temples and tombs with frescoes of matchless colours and unfading splendour; and lastly, and not least significantly of his chemical skill, embalmed his dead for historic contemplation and wonder, if not for the houris and joys of the everlasting Hades.

The Hindoos, who in their vast temples sought to do honour to the gods, and in pertaining to a knowledge of the cosmic atoms, to teach the general cosmogony; and the Chinese, rejoicing in quaint edifices and quainter attire, that borrowed astronomical em-

blems for their faith and the propitiation of their deities, were equally alive to the arts of chemistry in their reduction of metallic ores, in the processes of dyeing, the fabrication of paper, earthenware, several salts, and possibly gunpowder itself. Chronologically or not, it is difficult to say, but the Phœnicians, welcomed for their higher arts by King Solomon, and ready to offer the inimitable purples of Tyre to the populations on both sides of the Mediterranean—nay, not content with the intercourse of the Great Sea, navigated their way through the Pillars of Hercules to the *Ultima Thule* of the geographical world of that day, and made their metallurgical zeal accessory to the exploration of Britain itself. In the plastic and pictorial arts, in bronze statuary and diverse artistic methods, the Etruscans proved their aptitude in chemistry as well as technology. In short, all the historical groupings or nations of antiquity left legacies to the world of their manipulative skill, blended with the practice of chemical arts, occasionally, indeed, displaying a degree of excellence in their workmanship that has not as yet been surpassed by modern operators.

The last breath of the love-inspiring Cleopatra marked the last flicker of the once glorious Egyptian lamp. Then came Cæsarism, that sought to carve Roman fame in every land, even at the cost of a ruthless destruction of the archives of the Pharaohs—an act of Vandalism on the part of Diocletian that future ages can never forget.*

* Gibbon, in his "Decline and Fall of the Roman Empire," chap. xiii., attempts to vindicate Diocletian's destruction of the "Ancient Books" of the Egyptians, on the ground of their containing but "mag-

Before an adverse fate had laid Egypt at the feet of the "Mistress of the World," classic Greece had come to the front with a freshness and radiance that almost shadowed the illustrious renown of the mighty empires of the East. Its people, as if favoured by the gods, presented a noble physique and a still nobler emulation. They won the esteem of the neighbouring nations by their mental character and vigorous defence of liberty; they enlightened mankind by their ethics and philosophic culture, and left most precious proofs of their architectural skill and sculptorial arts, unquestionably the grandest achievements of inspired art ever presented to the gaze and open admiration of man. The historical Greeks were truly men of ideas and vast conception, able to embody natural phenomena into universals and generalities in appropriate symbols. If more disposed to hazard theoretic views on the cosmogony than to test their opinions by methods of induction, and more given to abstract and metaphysical studies than to the painstaking efforts demanded in physical research, their penetrative eyes could not overlook the more obvious claims of chemistry, were it only for the aid it offered them in the arts of war and

nificent pretensions" to the making of gold and silver and other indications of "mischievous pursuits." Surely the Alexandrian Library, with all its rare manuscripts and recondite lore, setting forth the arts and discoveries of one of the oldest dynasties of the world, older than those of Biblical history, was worthy of preservation. The Romans, in all their greatness, could not vie with the Egyptians in the higher branches of human knowledge; nay, more, after eighteen centuries of Christian life, experience, and enlightenment, the European has failed to reach the eminence attained by the Nilotic races in some departments of mechanics and chemistry.

peace, and not less as a source of gratification to their æsthetic tastes displayed in the colouring of their statuary, and the decoration of their magnificent temples.

The higher minds of Greece—excepting the learned author of the "Historia Animalium"—tended more generally to philosophy than science, and, it may be supposed, saw but dimly into the chambers of chemistry. In a subsequent chapter, treating of the atomic theory, it will be shown that the Greeks revelled in hypothesis, apparently less partial towards the experimental basis of the statics of chemistry than the natural history of atoms, upon which problematic formation they could found endless speculations and doctrines. Now and then they came across chemical phenomena without recognising their import. Thus Empedocles, on burning wood upon the surface of a cold body, observed during the process smoke or *air*, followed by flame or *fire;* then moisture or *water* deposited on the cold substance, whilst ash or *earth* remained: so the wood had been resolved into its co-efficients or elements—fire, air, water, and earth. Though the aims of Empedocles were to illustrate his cosmic ideas, he had made a true chemical experiment, and so far offered an explanation of the results obtained. This was the first instance of the art of analysis, with a view to discover the ingredients of which matter was composed, and the doctrine formed upon it the first starting-point of chemistry in history. Further inquiry might have led to beneficial purpose; but the Greek, somewhat hasty in his generalisations, invested the four elements with universal application, and,

what was worse, indoctrinated the world of thought with the same dogma and unwise limitation.

The military prowess of the Romans not only insured them dominion over the sea board territories of the Mediterranean—that "Great Sea" upon whose shores the grandest drama of human history has been played by the greatest actors on the world's stage, a drama revealing in its many acts the formation of political institutions, and the antagonistic forces of race, the rise of republics, the downfall of empires, and all those organic critical periods in the natural order of human progress in which Polytheism or Monotheism, Christianity or Rationalism have alternately claimed jurisdiction and power over the thoughts of mankind—but extended far beyond all previously ascertained geographical bounds. The Roman of the Augustan age, might well boast that he could march with safety under the protective ægis of his citizenship through Caledonia "stern and wild," or take his *siesta* amid the glowing charms and sunny favours of Ma-n'-lak. All the arts and sciences—all governments, records, and beliefs—all traditions and customs were marshalled; nay, all history, was culled and digested on behoof of Imperial Rome. This concentration of the intellectual forces and industrial arts, tending to man's cultured aims, should have been productive of great advantage not only to the Roman people, but to the world at large. Such probabilities, however, were not realised; for whilst fully appreciating the eloquent outpourings of Lucretius and Cicero on the cosmic atoms, and their vivid resuscitation of the Greek philosophy, it is doubtful if the Romans, the most practical people of the

world, threw any light upon the real aims and operations of chemistry. The pages of Celsus, Dioscorides, and Galen afford proofs of an ample *Materia Medica* in the hands of the Roman physicians, including the more important metals and their compounds, saline substances, and animal and vegetable products; and thirty years ago the archæological researches of my lamented and accomplished friend, Sir J. Y. Simpson, fully set forth the fact of the Romans in Britain being conversant with ophthalmic surgery, and the treatment that rested on chemical agencies. Unfortunately, nearly all the knowledge that had been gathered of the chemical arts in the days of Rome's highest ambition got scattered to the winds in her decline and fall. *Sic transit gloria mundi.*

In this faint sketch of the progress of chemistry, it is needful to pass over the polypharmists of Arabia, *e.g.*, Rhazes, of 200-volume fame and marvellous erudition; Alfarabius, courted for his wisdom by caliphs, and still credited as the first of cyclopedists; and Avicenna, the prince of physicians, who got glimpses of a true chemistry amid his alchemical pursuits. Then we come to Albertus Magnus, the distinguished European of the thirteenth century—a truly great man, of whom it was correctly written:—"*Magnus in magia naturali, major in philosophia, maximus in theologia.*" Albertus saw beyond the vista of Avicenna; nay, traced chemical *affinity*, and employed the word in its precise sense, as designating the combinations of bodies, and the effects of nitric acid as a solvent. His pupil, the "angelic doctor," Saint Thomas Aquinas, lagged

not far behind, and among many discoveries, saw the nature of an amalgam. Then arose our countryman, Roger Bacon, known as a monk, and often named a magician; yet the latter epithet he disclaimed, and tried to contravene by his treatise "De Nullitate Magiæ." His "Opus Majus" proved his recognition of the experimental method of investigating natural bodies. Raymond Lulli, pupil or not, followed Roger Bacon's footsteps, without, however, abandoning the hope of finding the philosopher's stone; nay, he is credited with having possessed it, and of having filled the coffers of his liege lord, the king of England, by his manipulations in the laboratory erected in Westminster Abbey. Towards the close of the following or fourteenth century, Basil Valentine of Erfurth appeared with his quaint symbolical designs of alchemical processes, and not without knowledge of many metallic compounds and the stronger acids, and various chemical operations and reactions.

The alchemistry of the Middle Ages offered large field for chicanery and charlatanism. There was the alluring search for the philosopher's stone, to transmute the baser metals into gold, and the universal elixir, to cure all the ills of the flesh, thereby conferring immortality on man—a grand consummation devoutly to be wished. Yet these alchemists were men of acuteness, and persevering inquirers into the mysteries of nature; their independent labours helped to pave the way to a fuller and better knowledge of the art, and ought to be held in grateful remembrance by mankind. Paracelsus thus wrote of his brethren:—"They are not given to idleness, nor

go in a proud habit, or plush and velvet garments, but diligently follow their labours, sweating whole days and nights by their furnaces.* They wear leather garments with a pouch, and an apron wherewith they wipe their hands. They put their fingers amongst coals, into clay and filth, not into gold rings. They are sooty and black, like smiths and colliers, and do not pride themselves upon clean and beautiful faces."

Whilst empiricism and mystic arts clouded the operations of too many of the brethren, there were notable exceptions to be found among these pioneers to a higher science, of whom Friar Bacon was a notable example; and his namesake, the Lord Chancellor of England, four centuries later suggested the method of interrogating nature by observation and experiment; and in the practice of these true modes of investigation, there in time arose from the furnaces and alembics a new philosophy that confounded all the reasoning of the ancients.

Putting aside Hermes Trismegistus, "the doctor of three parts of the wisdom of the world," also the Egyptian and scriptural authorities, the esoteric angels with naughty longings for Eve's fair daughters,

* The alchemist's laboratory comes down to us as "a gloomy, dimly-lighted place, full of strange vessels and furnaces and melting-pots, spheres, and portions of skeletons hanging from the ceiling; the stone floor littered with stone bottles, pans, charcoal, aludels and alembics, great parchment books covered with hieroglyphics; the bellows with its motto *Spira*, *Spera*, the hourglass, the astrolabe, and over all cobwebs and dust and ashes. The walls covered with various aphorisms of the brotherhood, legends and memorials in many tongues, passages from the Smaragdine Table of Hermes Trismegistus, and looming out from all in great capitals ΑΝΑΓΚΗ."—("Birth of Chemistry," *Nature*, March 20, 1873).

Maria the Jewess, and other mythological entities, it may in part be confessed with Monsieur Dumas, the French chemist of our day, that "practical chemistry took its rise in the workshops of the smith, the potter, or the glass-blower, and in the shops of the perfumer, the first elements of scientific chemistry dating no further back than yesterday."

To the Hon. Robert Boyle, the first President of the Royal Society of London, the science of chemistry owes no small amount of obligation. He entered his protest against alchemistry, and raised valid objections to the introduction of morals and politics into philosophy. His experimental inquiries have ranked him among the first of the true chemists. He saw that metals increased in weight when calcined in the air, as had been surmised in the year 1630, by Rey of Perigord, and was cognisant of the air containing a principle which is consumed during respiration and combustion. Dr John Mayow, of Oxford, was a worthy contemporary of Boyle's, and had definite notions as to the combination of acids and alkalis; they and the inventive Robert Hooke, who was more of a philosopher than a chemist, contributed several papers to the Royal Society, the character of which rests mainly on the observation and the description of what has been called the *qualitative* side of phenomena, yet not without real value in building up the science.

Sir Isaac Newton was more or less an alchemist, who spent days and nights in trying to discover the secret by which grosser metals might be changed into the more refined of gold or silver; but he failed, like the more ancient brethren in the art. His hypo-

thetical and grandly deductive investigations found their real place and value in the walks of Natural Philosophy : all his tentative experiments in chemistry were but haphazard guesses recorded in his celebrated "Queries."

Among others of real note was Van Helmont, the mystic Belgian and psychologist, who helped to develop pneumatic chemistry by observing the properties of several elastic fluids, and who also described some of the qualities of the carbonic acid gas in the *Grotto del Cane* near Pozzuoli. But the most conspicuous and able man of his time was Stahl, of Anspach, who propounded his phlogiston theory in 1697, possibly borrowed in part from Albertus Magnus,—a theory that took well with the cultivators of chemistry early in the following century, and retained its grasp for upwards of a hundred years, checking in part the thoughts of Black, Cavendish, and Priestley, and for a time at least modifying the larger views of Lavoisier, and thus proving how tenaciously a doctrine once established will hold its own against the innovations of modern and more correct science.

The eighteenth century, that ushered in Stahl's theory with such force, happily provided chemistry with some of its most renowned cultivators and discoverers, notably Lavoisier, whose powers of generalisation cast the balance against the doctrines of combustion propounded by the learned Professor of Halle, and opened out fresh fields of inquiry of large interest and importance.

The Stahlian theory of phlogiston did service in its way, in laying hold of a common principle in facts

more or less analogous, *e.g.*, those of combustion, calcination, and acidification, though it erred in attributing these processes to the dissipation of a peculiar ingredient. The new theory advanced by Lavoisier excluded the analogies, and offered an explanation more conformably to their nature, in the addition of the pervading element oxygen. This was the turning over of another page in chemical history, upon which was inscribed the freshest interest.

Chemistry was manifestly in the ascendant throughout the eighteenth century, and among the leaders of the science were Scheele, Black, Cavendish, Priestley, and Lavoisier; others of close secondary rank were Boerhaave, Bergman, Watt, Wenzel, Richter, and Higgins. A few words on some of the chiefs may be offered here, whilst a passing remark is due to Benjamin Franklin, the printer, for his revealing a new phase of electricity that excited the attention of the philosophic intellects of the world.

Charles William Scheele, the Swede, and pupil of Bergman, was an able analyst, who proved the character of several salts and gases, notably oxygen, without being aware of Priestley's earlier knowledge of the qualities of the gas. He discovered arseniate of copper, known as a pigment under the name of Scheele's green, and also succeeded in obtaining for the first time the active poison prussic acid in a separate form. Scheele justly ranks with his countrymen Linnæus and Berzelius, and the three constitute a trinity of eminence, in their respective walks, of whom the greatest nation in Europe might well be proud.

The investigations of Dr Joseph Black of Edinburgh, as early as the year 1754, on the difference between

mild and caustic alkalis, have been regarded as the inauguration of the *quantitative* method in chemistry, and the first instance in which the nature of chemical combination and decomposition was clearly pointed out. These ideas were afterwards extended by Lavoisier to the whole range of chemical phenomena. About the year 1760 Black evolved the theory of latent heat, on which his scientific fame mainly rests, a theory from the practical application of which his pupil and assistant, James Watt, obtained a great success in his own line, the chemico-dynamical—so great indeed, that it has revolutionised the mechanical powers of the world, and added a thousandfold to man's enterprise and superiority.

The most renowned man in science yet born to the aristocracy of England was the Hon. Henry Cavendish, nephew to the third Duke of Devonshire. He was educated at Cambridge, and devoted his whole life to scientific investigations; nay, shunning society and women, and all the pomps and vanities of the world, till philosophy marked him for her own. To him we owe much of the foundation of pneumatic chemistry. His discovery of hydrogen, and the radical difference between it and nitrogen, led to projects for aërial navigation or ballooning. He ascertained the composition of water from the union of two gases—oxygen and hydrogen—a discovery of greater importance than any single fact yet arrived at by human ingenuity in the whole range of chemistry. He contributed to the Royal Society of London many papers on electricity, astronomy, and historical subjects. All his experiments and processes were of a most finished nature, displaying an accuracy and beauty

that had never been equalled. He had but one servant, and lived the life of a recluse. His science was his mistress and delight; yet he was the largest holder of bank stock in England, probably to the extent of a million, besides a landed estate of £6000 a year and tens of thousands at his bankers!

If Henry Cavendish's walk was confined to his own laboratory and the meetings of the Royal Society, Dr Joseph Priestley was one of the most conspicuous men of his epoch, and as bold and fearless in politics and theology as he was broad and successful in science. He discovered oxygen, and contributed largely to our knowledge of electricity, and vision, light, and colour, and would have done vastly more, if he had not suffered dire persecution from Calvinistic fanatics. He led a grand and virtuous life, and his memory was gloriously honoured by an *éloge* from the great Cuvier, addressed to the Institute of France. Both Cavendish and Priestley rendered great service to the cause of chemistry, and left imperishable names to the country of their birth.

It is difficult, and not always safe, to institute comparisons on the respective merits of men of science, inasmuch as prejudice and nationality occasionally disturb the historic balance; yet I may be permitted to remark that the English, German, and Swedish chemists of the eighteenth century directed their aims to practical methods and exposition, in time realising valuable data, whilst Lavoisier, the noble Frenchman, being more solicitous for general principles, sought by experiment and logical precision to establish a comprehensive groundwork for the science. Had Lavoisier not fallen a victim to the revolutionary

furore of 1794,* he would have been the Laplace of chemistry, eclipsing all his contemporaries, and probably anticipated the important researches of Dalton.

French writers are prone to claim the majority of discoveries in science. Even Wurtz has written:—"*La chimie est une science Française, elle fut instituée par Lavoisier d'immortelle memoire.*" A late writer, Ferdinand Hoefer, in his history of Physics and Chemistry (1872), is more just, but not correct as to the individual Englishmen, in stating:—"*Tout en suivant chacun une route differente, trois chimistes ont fondé, vers la fin du dix-huitième siècle, la chimie moderne, Priestley, Scheele, et Lavoisier, un Anglais, un Suédois, et un Français.*" Cavendish, by far the greatest name in English chemistry up to the time of Dalton, has been strangely overlooked in this historical criticism of Hoefer's.

The investigations of Wenzel, Higgins, Richter, and others, whose names will appear as claimants to the doctrines expounded by Dalton, were in the

* In reference to the fate of Lavoisier, one is tempted to exclaim, in the words of the noble Madame Roland on her way to the same martyrdom—"O Liberty, what crimes are committed in thy name!" Seized in his laboratory by the *gens d'armes* of the bloody Convention, and knowing that a few hours would decide his fate, Lavoisier asked permission to finish the experiments in which he was engaged, and to record the results before he bade farewell to science and life!

A historical parallel might be drawn between our Sir Walter Raleigh, one in a long bead roll of famous Englishmen, whose behaviour in his last hours comported with the philosophic calmness of Lavoisier: the one was a martyr to the monarchical hate of a vile king, the other a victim to republican furor. Fortunately, neither autocrats nor republicans can impair the honourable worth and grandeur of such lives as Raleigh's and Lavoisier's; history is proud to offer the homage due to immortality.

same direction as Lavoisier's, and should have exercised a marked influence, inasmuch as they contained part of the germ or scheme that in Dalton's hands led to great results.

The crowding of men of genius to the goal of the last century naturally betokened well for the progress of chemistry in the present; yet much light was required to clear away the misty phlogiston atmosphere, and to give tangible form to the *dicta collectanea* furnished by the workers of the past. At the dawn of the nineteenth century England rose to the foremost position, and France and Sweden nobly closed up the ranks of scientific competition. In the wholesome development of science, every step gracefully follows another, and every movement adds life and enterprise to it. True science recognises neither nationality nor creed, nor political bias; thus, the rivalry of the Saxon and the Celt was healthfully bestowed in promoting the public good by the spread of chemical knowledge.

As the phlogistic theory fell into the shade, the discoveries of Galvani and Volta happily came in aid of chemical investigation, opening out a new world of research, that has already yielded marvellous results, and bids fair to eclipse the cravings of the most poetic imagination. Messrs Nicholson and Carlisle, in 1800, then Cruikshanks, Henry, Wollaston, Pfaff, Biot, Thenard, and perhaps more than all, Berzelius, laboured in the work, and showed that various compounds were capable of decomposition by electricity. These competitors, however, were speedily outstripped in the race by Humphrey Davy, the woodcarver's son, of Penzance, and "mere

apothecary," who, entering upon a comparatively new field of chemistry, startled his contemporaries both at home and abroad by the brilliancy of his discoveries.

Though necessarily sparing in historical comment, and afraid of selecting single examples from a galaxy of worthies, I must not overlook Berzelius, the Swede, of the highest rank in science, so grandly methodical in all his work, and no less inductive in his beautiful methods of experimenting; Gay Lussac, of noble aim and nobler achievement; Berthollet, the voluminous writer; Thenard, Proust, Fourcroy, and others of the French school; all of whom highly distinguished themselves; and, ranking with these were Wollaston, Professor Thomas Thomson of Glasgow, and the famed Count Rumford.*

Of this noble band of workers and discoverers, to whom the civilised world is so largely indebted, none had the good fortune to meet the exigencies of the hour, that called for a new hand to bind the accumulated and heterogeneous facts into a homogeneity of doctrine, upon which chemistry might step forth and claim high place among the pure sciences.

The light so long and earnestly solicited, to dispel

* My scientific friends will please to look upon this introductory chapter as meant for the general reader. So slight a historical sketch of the rise of chemistry can only offer a glance at the tentative efforts of the early workers in the field, polypharmists, alchemists, and the like. At the same time, it may serve to show the slow growth of the leading principles upon which a true science has at length been founded.

Those who wish for an interesting *resumé* of the rise and progress of chemistry will do well to consult Mr G. F. Rodwell's interesting volume on "The Birth of Chemistry," issued as one of the "*Nature Series*," and with apt illustrations by Macmillan & Co., 1874.

the mists overclouding the dawning science of chemistry, and to give precision and tangible method to its study and profitable pursuit, came from a very unexpected quarter of England—a city of cotton interests and hard cash, not without laudable ambition to become "the Cottonopolis of the North." The lamp of knowledge got trimmed amid the din of shuttles and spinning-jennies and multifarious handicrafts by an unobtrusive Quaker, pursuing his calling of schoolmaster in a back street of Manchester, and thankful to earn the wages of a skilled artisan. Yet this humble individual, scarcely known outside the pale of his peculiar religious denomination, was daily absorbed in profound intellectual studies, the discoveries arising from which placed him among the great chemists of the day, and ranked him in a position only secondary to that of the immortal Lavoisier.

The early history of the man was in every way so antipodal to the favours of fortune, that the most imaginary and hopeful of temperaments could not have foreshadowed for him any great rise in the world, much less a claim to distinction in the higher sciences. Of the humblest origin, and apparently born to manual labour and the lowest grade of social life, schooled in a retired hamlet of the North country, and reared amid coarse bucolicism and marked barrenness of thought, he had no propitious patron to advance him to the associations and emulation of our public schools, and no friends in court to secure him a place among the humblest *alumni* of our Universities. In short, possessing none of the advantages surrounding ingenuous youth, and springing

from a poor household on the bare uplands of Cumberland, away from the main arteries of England, and the great centres of industry and enterprise, John Dalton appeared on the horizon of inductive research, a self-taught man, whose genius and assiduity elicited an original and comprehensive law in the Physics of Chemistry, that gave breadth, and form, and solid structure to a science deeply interwrought with the essential interests of mankind.

CHAPTER II.

"*It is not so essential to have a fine understanding, as to apply it rightly.*"—DESCARTES.

GEORGE FOX IN CUMBERLAND — EAGLESFIELD — JOHN DALTON'S ANCESTORS — HIS BIRTH, EDUCATION, AND FRIENDS—SCHOOLMASTER AND PLOUGHMAN—ADIEU TO HOME.

WHEN George Fox, the Leicestershire shoemaker, could find no means to salvation at the hands of the spiritual directors of the State Church, some of whom advised him beer and concubinage, others tobacco and psalm-singing, he sought the Scriptures for himself, and speedily made up his mind to doff his leathern apron, and to go into the world on a mission of evangelisation. In his tour northwards he spent some time in Cumberland, and obtained a great success by carrying the pluralist Vicar of Brigham off his tithe legs, and all his congregation, to a free ministry. The religious fervour of the Cumbrians was heightened by the preacher appearing in a buckskin suit of his own tailoring, greased by use and compulsory companionship with the filthy occupants of filthy jails, to which his strong speech and heterodoxy often consigned him. Fox addressed an open-air-meeting at Pardsey Crag in Brigham parish, and among the motley thousands who flocked to his standard were the ancestors of

John Dalton of Eaglesfield. The growth of Quakerism in Cumberland had no small influence in promoting the educational and religious status of the lower orders, to whom the great text was daily proclaimed —"Search the Scriptures." *

In the parish of Brigham, and not more than three miles south-west of the market town of Cockermouth, stands the village of Eaglesfield, which forms part of the ancient manor and borough of Cockermouth. Eaglesfield enjoys some historic repute from giving name or title to a learned ecclesiastic of the Plantagenet epoch, "Robert de Egglesfield," chaplain to Edward the Third, and founder of Queen's College, Oxford—an institution that has conferred many lasting advantages on Cumberland and Westmoreland men of Oxonian merit. A greater honour fell to Eaglesfield when it gave birth to John Dalton, whose name is indelibly recorded in the archives of the world's science, as one of the leading philosophers of his age and country.

The township of Eaglesfield situated on the undulating limestone formation of West Cumberland, previous to the enclosure of the waste lands, and the introduction of good husbandry about half a century ago, would offer little more than herbage for rough

* "Search the Scriptures," coupled with Fox's soul-inspiriting exhortations, induced many to become readers who had previously neglected the very alphabet. It is well-known that the reading community of England was comparatively small in the seventeenth century, and that the agricultural districts were the worst in this respect; nay, so little progress had been made a century later, that Edmund Burke computed the reading population of this country at only 30,000 !—probably much too low an estimate, and not in accordance with what is generally understood to have been the state of education in Cumberland.

kine, and hard lines of life to the scattered inhabitants. Bucolic life of the boorish sort prevailed in the hamlet, in which farmers of small holdings, their clodhopping service, and common craftsmen, laboured for a subsistence of a vegetative or earthy sort. The village consisted, and its features are not much altered to-day, of old-fashioned grey stone dwellings, regular in their irregularity of position, and in structure dilapidated; straggling manure heaps, a bit of dirty common or village green, and dirtier duckpond, backed by a dingy "smiddy," to which the loungers with their gossip and tittle-tattle daily gravitated to discuss the news of the district. There was little to affect the stagnant life and clodhopping proclivities of the locality, beyond the calls of the huckster, or the cries of the travelling tinker; and its passive quaint domesticity was only occasionally ruffled by the loud bravadoes of "John Barleycorn," and the louder reproachings of his disappointed spouse. Eaglesfield folk were a stiff race of countrymen, presenting stalwart forms in coarse woollen garb of home-make, and the horny hands and sweating brows of labour, rejoicing in hamlet isolation, and heedless of the contentions and turmoil of the world.

The redeeming feature to what might have been doltishness and dotage in the Eaglesfield district, was the presence of Quakerism, a light of itself both in precept and example, and ever tending to habits of discipline no less than mental and moral improvement. This light shone on the hearth of the Daltons, and was reflected from other sources that proved of high import in the training of John Dalton, nay, of

lasting influence in his long career of patient inquiry and investigation.

As pilgrimages to the shrines of saints draw thousands of English Catholics to the Continent, there may be some persons in the British Islands sufficiently in love with science, not only to revere the memory of its founders, but to wish for a description of the locality and birth-place of a great master of knowledge—John Dalton—who did more for the world's civilisation than all the reputed saints in Christendom. To those, who may be termed scientific pilgrims, the following brief outline may not be unacceptable.

On approaching the village of Eaglesfield by way of Brigham (a railway station two miles from Cockermouth, and about thirty from Carlisle), the road diverges; the broad and continuous line leads to the "Friends' Meeting-house" and burial ground, and the higher parts of the village; the narrower road sweeps to the left, and takes you direct to "John Dalton's house"—pointing south, and towards you—its gable forming the boundary of a lane that gives access to the centre of the village. The house in which Dalton was born has been altered and much improved since his day; its low thatched roof has been raised and slated; the partially boarded loft converted into upper rooms; its small leaden windows displaced by larger panes of glass; and the greystoned facing of the building white-washed: still the general features of the interior of the humble dwelling remain pretty much as when occupied by weaver Joseph Dalton, and his active spouse Deborah—the parents of John Dalton. By a small porch showing quaint recesses for

pots and pans, you enter the kitchen or general sitting and business-room of the family, where, probably, Joseph had his loom placed; from this apartment, by a narrow passage, you reach a smaller room immediately adjacent, in height and width six feet, and in length fifteen feet. The recess to the left of the door-way was occupied by a chaff-bed, upon which Joseph and Deborah slept, and there John Dalton, the chemist, first saw the light of day, on or about September 6, 1766.

In his annual visits to Eaglesfield when blessed with fame and fortune, John Dalton would occasionally walk into the domicile of his birth, and point out to some of his old friends, who accompanied him, the domestic arrangements that surrounded his infancy, the fireplace open to the chimney, the position of the "old settle," and his own three-legged stool; the dresser with its pewter plates and horn spoons; and always with a smile on his countenance pointed his stick to the recess occupied by the corner cupboard. Liking sugar and sweets, this cupboard was the earliest idol of his fancy, and in trying to obtain a footing whereby to reach the latch, he took the novel mode of kicking the wall beneath it with his calkered clogs. This was hardly an act worthy of a young philosopher, who could have used the chair with little risk of detection, whereas the plaster on the floor exposed his naughtiness, and led to a severe whipping.

The ancestors of John Dalton were truly sons of toil, either engaged in rough husbandry, or as artisans of the common sort; apparently content with their

station in life, and thankful for a livelihood that demanded thrift and economy to make ends meet. Living on rough fare, and clothed in rougher garb, their physical requirements got easily supplied; the mental appetites would claim little or no consideration. They realised the saying of the Roman philosopher, that wealth consists not in having great possessions, but in having small wants. The highest ambition of such men as the Daltons was to possess a cottage and a small garth or close of land for a cow's summer grazing;* and he must have been a poor craftsman who could not in a few years save earnings to acquire both, when land and labour were of so little value.

John Dalton was more lucky in his genealogical tracings than the famous Daniel Defoe, inasmuch as he could go back to his great grandfather on the maternal side, whose name was Thomas Fearon, born at Eaglesfield in 1658, and who died there in 1704. In the year of the Great Revolution of 1688, this Thomas Fearon married Mary Gill of Eaglesfield, at Pardshaw Hall Meeting-house. There were thirty-five witnesses † to the marriage document.

* There was a large common, or portion of unenclosed ground extending for miles around Eaglesfield, on which the villagers drove their cows, donkeys, and geese, occasionally spending half a day in finding their live stock, in their wild rambles; and it is highly probable that weaver Dalton had a cow on this rough pasturage, and that he occasionally benefited by his father's or brother's paddock at suitable seasons.

† After the simple form of marriage of Quakers has been gone through at their Meeting-house, the chief point being a mutual declaration by the respective parties of their willingness to take each other as man and wife, and of course to love each other affectionately, the friends of

Little or no information can be offered on the social position of Thomas Fearon;* probably he was a yeoman, who had some closes of land, the whole or portions of which he bequeathed to his daughter Abigail, born in 1690.

Now the Daltons come into view by a Jonathan Dalton, shoemaker, and grandfather of the subject of this memoir, marrying Abigail Fearon, daughter of the aforesaid Thomas and Mary Fearon, at Pardshaw Hall Meeting-house in 1712. "Nineteen witnesses." To this marriage there was issue *Jonathan*, born June 4, 1715; *Anne* in 1717; *Ruth* in 1719; *Abigail* in 1726; and *Joseph* on September 25, 1733. Passing over the daughters of Jonathan and Abigail Dalton, let it be said that *Jonathan*, their eldest son, became a farmer; and *Joseph*, their youngest son, of special interest in this narrative, was put to handloom weaving. Jonathan Dalton, senior, shrewd and observant, pursued his craft with diligence and success; and in 1727,† purchased some freehold and customary land,

the newly-wedded couple step forward, and attach their names to the formal wedding document; and they are designated "the witnesses." A certain amount of respectability is attached to the numbers who sign, as proving the popularity of the contracting parties.

* Among the old deeds of Dr Dalton, there is noted (January 1, 1700) a purchase deed of lands at Eaglesfield from John Leayths, by Thomas Fearon of Eaglesfield, yeoman.

† From the same deeds the following record is taken:

6 Feby. 1695. Purchase of lands at Eaglesfield, from John Fletcher of the Hill Blindbothel, by Samuel Robinson, cordwainer, and Mary Fearon, spinster, both of Eaglesfield as joint tenants, so that survivor would get the property, which consisted of a messuage and land, part of which laid before PETER Dalton's house, price £43.

4 Aug. 1727. Purchase of freehold and customary land at Eaglesfield, from John Iredale of Cockermouth, tanner, by *Jonathan Dalton*

from John Iredale of Cockermouth, price £74; and subsequently became possessed of more land and hereditaments, the value of which, long after his decease in 1772, and that of his son Jonathan in 1786, did not exceed £35 a year. Whether this holding of land accrued to his own industry, or was part of his wife Abigail's dowry, is a matter of conjecture, but after his death in 1772, his son Jonathan inherited it. This Jonathan Dalton married Mary Thompson of Gilcrux in 1741, at Pardshaw Hall Meeting-house, but had no issue. His death is recorded, "Jonathan Dalton of Eaglesfield, yeoman, aged 71 years, November 3, 1786." His widow survived him four years, and may be heard of again in this memoir as "Aunt Mary;" on her decease, December 2, 1790, the property of her late husband fell to his brother Joseph Dalton, weaver.

Joseph Dalton, the father of John Dalton the philosopher, was a common country weaver, who showed no parts, and earned but small pittances by his shuttle.* He was looked upon as somewhat inert,

of Eaglesfield, yeoman, price £74. Jonathan Dalton *the elder* is admitted on the Court Rolls in same year.

24 Apl. 1749. Jonathan Dalton the elder surrenders the customary land to his son *Jonathan the yr.*

25 March 1751. An award between *Jonathan senior, and Jonathan the younger*, respecting their lands in Eaglesfield—both described as yeomen.

20 Decr. 1787. Jonathan Dalton, eldest son and heir of Joseph Dalton, who was only brother and heir of Jonathan Dalton, deceased, is admitted tenant of the land purchased from John Iredale. Dr Dalton is afterwards admitted as brother and heir of Jonathan.

* The operations of the handloom weaver of a century ago were essential in the rural districts of Cumberland, where every one wore

if not a feckless sort of man; yet he had courage enough at the age of twenty-one years to go miles from home, to court Deborah Greenup of Caldbeck, whom he married at Cockermouth Meeting-house on June 10, 1755. The Greenups of Caldbeck were a respectable family of yeomen; and Deborah, who linked her interests with weaver Dalton, was an active-

cloth of home-make, or linen of their own spinning. For the rougher wear of husbandmen the sheeps' wool was washed and spun with little or no preparation for the weaver; and from this material the "grey coats" were made, that led to a distinctive appellation being used for the yeomen and farming class—"the grey coats of Cumberland." Such coats are still to be met with in outlying districts, and my heart would rejoice if the honest independence and patriotic fervour of the men who fought so many political battles could still be recognised under the old "grey stuff." A better sort of wool was subjected to repeated washings and bleachings for the purpose of finer clothing and blankets; and of these latter such as were made in the "good old times" lasted for three generations. The days of "shoddy" and shabbiness of purpose had not then dawned on the commercial world of England.

The weaving of linen was of equal import. The small landed proprietors and farmers used to grow their own flax; and in the Eaglesfield district this is very distinctly shown by the name Hemplands, corrupted into that of Hemplin, being still applied to fields on nearly every farm. After beating and other preparatory processes the flax or "lin" was spun by the "small wheels" then in use in every country kitchen, and made ready for the weaver; the "large wheels" were applied to wool. Forty years ago the kitchens of respectable farmers during the winter evenings offered a refreshing sight in the mistress of the house and her maids busy at the whirl-go-round of the "small wheels;" whilst the master and man-servants on the other side of the ingle nuik talked over farm work and the customs of the country side.

In Dalton's youthful days, the manufactures of this country were almost entirely domestic. In the farm houses and cottages were fabricated almost every article of clothing which their occupants required. The growth of our population, and still more the introduction of machinery, put an end to this domestic independence; and now—

"The wheel is silent in the vale."

minded, energetic woman, from whose veins it may naturally be supposed her son John gained a share of his best blood; if he did not in part inherit the observant character of his grandfather, Jonathan Dalton, who, like many of the sons of Crispin, displayed both acumen and intelligence. It is supposed that Deborah brought a small dowry to her husband.

By this marriage of Joseph Dalton with Deborah Greenup there were six children, three of whom—namely, Jonathan, Mary, and John—grew to years of maturity. Jonathan was born on September 9, 1759; Mary on January 24, 1764; but there is no record nor registry whatever of the birth of John Dalton, the subject of this memoir. Both parents were "Friends," and had hitherto, as seen in their daughter Mary's birth registration, conformed with the rules of the Society; and there is no evidence or even indication of their having departed from them. Was the omission of John Dalton's name from the Quaker registry of births purely accidental; or was the birth of a strong boy so passively viewed at Eaglesfield that they cared not to make any record of the fact, either in the Family Bible, where all domestic events of import got inscribed, or the registry book of the religious denomination of the parents? As Quakers have no faith in water baptism and priests, there was no christening of the lad, therefore no godfather's or godmother's testimony to be had, and of course no parochial register of John's advent. His father had evidently overlooked the registration, or deemed such a form of little or no con-

sequence, seeing that his youngest son's inheritance might be little more than the trappings of a weaver's loom, the corner cupboard, and "bits of furniture." It was only when John Dalton attained eminence that the world began to inquire the date of his birth, and he, being appealed to, and knowing nothing of the pleasures of birthdays, those first intelligible memoranda of the youthful mind, could not answer the question satisfactorily. After various inquiries in the district, more particularly of women who had been in the same "interesting situation" as Dame Deborah, it became established that John Dalton was born on September 6, 1766. The historical reader will recall the fact of Voltaire's birth being unknown, and the Duke of Wellington's remaining a matter of doubt as to the month at least, and the present narrative is not less strange, *quoad* the birth of a great chemical philosopher, whose coming into the world could only be vouched for by the furbished-up memory of puerperous neighbours, aided by the village gossips and "smiddy" oracles.

As soon as John's fingers were pliable enough, he had to hold the spools, to prepare the shuttles, and do other light work attached to the weaver's handicraft. In due season he was sent to Pardshaw Hall School, two and a half miles distant from Eaglesfield, and placed under the tuition of Mr John Fletcher, the son of a highly respectable Quaker yeoman, and a youth of attainments vastly superior to his age. Mr Fletcher had in neighbourly kindness undertaken the duties of the school during the master's absence, and

getting a liking for the work, continued to act till he attained his majority.

John Dalton was by no means a quick boy, neither sharp at work nor demonstrative at play, but steady-going in all his actions, and ever faithful to his book. The prominent and noticeable feature of his early youth was constancy of purpose; indeed, this plodding and thoughtfulness grew with his growth, and became a chief characteristic of his manhood. Mr Fletcher seems to have marked the promising traits of the boy, and lent him every aid and encouragement from his initiative rudiments onward to his study of mathematics. Under Mr Fletcher's good guidance Dalton gained those habits of self-reliance and indomitable perseverance which enabled him to go through arithmetic and navigation before the completion of his twelfth year. It is pleasant to note here that John Dalton ever spoke in the highest terms of the excellent training and instruction he received at the hands of his first and only schoolmaster,* whose friendship he esteemed through life, and whose memory he did not cease to revere.

John Dalton early afforded proofs of his mental superiority, and the story is told to this day at Eaglesfield, of his curiosity being excited by a dispute that arose among some mowers in a hayfield, as to

* The Quaker schoolmasters were by far the best of their kind in these northern parts. Their own home training, orderly habits, quiet demeanour, and self-denial, constituted a valuable groundwork to the patience and painstaking efforts required in the daily tuition of obstreperous youth; whilst their superior intelligence and culture made their written *formulæ* tangible to the learner, and gave pleasant colouring to their indoctrination in history and literature.

This subject has been adverted to in my "Life of Dr John Heysham."

whether sixty square yards or sixty yards square were identical. At first he saw no difference between the two statements, but maturer consideration of the subject showed him his error. The solution of the question by a boy of ten years old did not pass unnoticed; and it was by such "feats of calculation" that he won the good opinion of the neighbours, and came to be recognised by his companions as their intelligent leader. Another instance of his precocity has come to my knowledge. One evening, on his way home from school, he was observed standing on the highest part of a hedge, delivering an extempore lecture to his schoolfellows on a subject that he believed he could enlighten them upon, and it is probable that he succeeded in imparting some information, or that his juvenile effort was gratifying to his audience, from whom were heard the exclamation—"Bravo, John!" and "Hip, hip, hurrah!"

If fortunate in having a teacher in John Fletcher, John Dalton was equally fortunate in securing the attention of Elihu Robinson, a Quaker gentleman of ample means and ampler knowledge, whose scholarship and philanthropy well entitled him to the designation of "the man of Eaglesfield," a century ago. The recognition of Elihu was a step in advance to the educational and social status of John Dalton, who, being invited to his house, could not fail to mark the difference between his father's lowly dwelling and sanded floor, dirty loom, and other appurtenances, and the carpeted parlour, library, and comforts surrounding his new patron, and his well-educated wife. As a true Cumberland worthy, independent of his being the friend and active promoter of John Dalton's

mathematical studies, a few words are here due to the memory of Elihu Robinson. If the reader could be favoured with a peep at Eaglesfield, as it presented itself exactly one hundred years ago, he would mark Elihu Robinson decked out in his three-cocked beaver, light drab coat, vest, and knee-breeches, yellowish-grey ribbed stockings, and silver-buckled shoes, all in the best style of rich Quakerism, fine and spotless, and walking in sober fashion through the village with silver-headed cane in support. Everybody bowed respectfully to the head of the village, a man of probity and learning, a benefactor of the deserving, and a thoroughly good neighbour. Elihu was probably the first of Cumberland's meteorologists, gauging the rainfall, recording the readings of the thermometer and barometer, noting the seasons and crops, and many natural phenomena; moreover, he had manipulative skill that was exercised on the construction of philosophical instruments, sundials, &c.* He was the friend of Collinson, the correspondent of Benjamin Franklin, of Dr Fothergill, of Anti-slavery Clarkson, and others of scientific renown, many of whom visited him at Eaglesfield. United with John Fletcher and other promoters of education in Cockermouth and Whitehaven, a Book Club was instituted, consisting of the magazines and chief works of interest obtainable quarterly from London. Thus literature and science had got a footing in West Cumberland, chiefly promoted by "Friends,"

* Mr William Sutton of Scotby, near Carlisle, who, on the paternal side, is a descendant of Elihu Robinson, possesses a well-constructed sundial of Elihu's.

and aided by Dr Brownrigg, of Whitehaven, and John C. Curwen, M.P., of Workington Hall. These West Cumbrians were men of real mark and magnanimity, who not only encouraged a love of letters, and the aspirations of science, but heartily co-operated in all the schemes of reform and practical philanthropy which dawned upon England after the declaration of American independence.*

Elihu Robinson invited John Dalton to his house, and offered to assist his studies along with a young man of the name of William Alderson, then in his service, and anxious for self-improvement. The two lads worked well together in the evenings, and though Alderson was much the senior, Dalton was generally ahead of him. When they came to a standstill in solving a problem, Alderson would fain have sought Mr Robinson's aid, but Dalton, with resolute aim and a belief in his own powers, would encourage his companion to renewed exertion, by remarking in broad Cumbrian dialect—"Yan med deu't" (one might do it). This phrase of John's always came to his rescue in difficulties, and, like a clerical text of pithy meaning, conveyed a wholesome sermon point-

* "The Society of Friends," collectively and individually, have ever taken a laudable part in social, educational, and political questions. Speaking from large opportunities afforded me of perusing the private correspondence, public manifestations, and parliamentary petitions got up by Cumberland Quakers, in the past as well as the present century, there can be no doubt that they have always been far ahead of the rest of the world in all matters affecting the welfare of humanity and the varied social interests dependent on governmental legislation. Every work they engaged in *pro bono publico*, found them zealous and indefatigable supporters, be it peace or pious endeavours, civil or religious liberty, the interests of our national commerce, or the education and happiness of our people.

ing to self-dependence, and persevering energy as the groundwork of success in life. The rivalry of the lads was healthful, but one day a dispute arose between them as to the best mode of working out a problem; Alderson would bet Dalton sixpence on the subject, but Mr Robinson objected to this, as all Quakers properly do to betting, and in place of the money wager, suggested that the loser should supply his companion with candles for their nights' studies in winter. This advice was acted upon, and Dalton came off victorious. Mr Robinson occasionally tested John's highest powers of thought by setting him an algebraic question, and after the lapse of an hour would return, and say, "Well, John, hast thou done that question?" "No," replied John, with his "Yan med deu't;" and another hour elapsing with no better result, John met his kind friend's interrogation by, "I can't deu't to-neet, but mebby to-morn I will." So he went home, slept over the problem, and rose again to work with refreshed brain that brought a solution to his difficulty.

The day's schooling at Pardshaw Hall, and the evening prelections of Elihu Robinson, were remarkable adjuncts to the development of a brain so broadly constituted as Dalton's, and the result was visible in his rapid advance to knowledge and superiority over lads of his own age. Of this position he seemed to be aware, or he would not have ventured on so bold a step as that of opening a school on his own account at Eaglesfield, in his thirteenth year. The retirement of Mr Fletcher from Pardshaw Hall school was probably the first incentive, as he never would have dreamt of opposing his friend; and the absence

of any school in Eaglesfield, and not less the limited means of his father, may have cast the balance in favour of the undertaking. Weaver Dalton had in John's infancy removed three doors higher up the lane, and upon the outside, or as some say, on the front door, of this dwelling John posted a large sheet of white paper, inscribed with a bold hand, containing the announcement of his having opened a school for both sexes, and on reasonable terms. This advertisement long did duty, and was also accompanied by another to the effect that "paper, pens, and ink" were sold within—two literary acquisitions to Eaglesfield, springing from the enterprise of a lad of twelve or thirteen years of age.

For a short while he taught his primitive school in an old barn, then in his father's house, and finally in the Friend's Meeting-house within the burial-ground enclosure. His scholars were of all ages, from infancy to seventeen. Some were so young, that he had to mount them upon his knee to teach them their A B C's; others were as old, and much older and bigger than himself, the proximity of the school having brought out lots of Eaglesfield lads whose education and manners had hitherto been grossly neglected. These last-named proved highly refractory scholars; so much so, that when John threatened them with chastisement for neglecting their lessons, or their naughtiness for playing at leap-frog over the graves of the dead—

> "Where heaves the turf in many a mouldering heap,
> Each in his narrow cell for ever laid,
> The rude forefathers of the hamlet sleep"—

they rebelled, and actually challenged him out to fight.

Here was a pretty *contretemps*, the scholars defying their master in open day, and in pugilistic fashion. How the young "dominie" got over an exhibition so offensive in character, and so derogatory to his dignity as head of the school, can only be inferred on reflecting on his dogged perseverance, and Quaker firmness under the most direct and worst forms of provocation.

Whilst busy teaching the lads and lasses of the hamlet, he was more busily engaged educating himself, and carrying on the good work the foundations of which had been so pleasantly laid by his attentive friends John Fletcher and Elihu Robinson. Those around him observed that, be the subject what it might occupying his mind, it got his undivided attention; he sat desk-bound and immovable, uninfluenced by noise or chatter, and not easily roused by repeated interrogations. His mental power seemed focussed upon a point, and no side-rays were permitted to interfere with the one concentrative thought falling on the work in which he was engaged.

"*The Ladies' Diary, or Woman's Almanac,* for 1779, containing new improvements in arts and sciences, and many entertaining particulars, designed for the use and diversion of the fair sex," came into his hands, probably through Mr Robinson's kindness, and he copied it *verbatim*. The existence of an almanac in his own handwriting, now in the possession of Mr John Robinson, of Eaglesfield, led some persons to suppose that John Dalton had at the age of thirteen years constructed an almanac for himself; whereas it is that of the *Ladies' Diary*—probably the first periodical that he had seen, and the first to call forth his spirit of emulation and competitive skill as an

arithmetician; for he and William Alderson in the winter evenings used to pore over the enigmas and mathematical problems it contained as long as the farthing dip,* or midnight oil, or the last flicker of the fire would enable them to read their pencil-markings on the rough slabs of Cumberland slate. This *Diary*, which, by the way, cost the large sum of three shillings, owing to the heavy taxation of that day on all kinds of knowledge, will claim more particular notice in the next chapter.

John Dalton, in the briefest of autobiographical records, which he had been solicited to contribute to Mr Roberts' "Book of Autographs," states that after two years of schoolmastering he was "occasionally employed in husbandry for a year or more." Why or wherefore this change of pursuit from that of teacher can only be inferred. He may have found his big and rebellious scholars too much for his guidance, or that his teaching was less profitable than a fair day's work of manual labour on his Uncle Jonathan's estate. From what I can gather from other sources, to be noted in the biography of Abraham Fletcher, of the pay of schoolmasters by weekly pence a century ago, I do not suppose that John Dalton realised more than five shillings a week as the master of Eaglesfield school; so that husbandry was as good a thing, if not better, in his instance,

* The term "farthing dip" is used to distinguish the crude, home-made tallow candle of that day—long in the stalk, of dirty-grey colour and rough surface—that was perhaps as much in favour as the little lamp that was made to do duty in consuming any oily refuse. A stick or turf fire, that emitted an occasional blaze, had occasionally to do the part of both candle and lamp, the eyes of the lieges being like the wiry framework of their bodies, and fit for any abnormal deviation of service.

seeing that healthful occupation in the fields cleared his brain, and fitted him the more for evening studies. At this period, when entering upon his teens, he can have had no ideas beyond the bucolic life around him; and the highest aim of his ancestors was farming, with the prospect of some day realising by wholesome industry the ownership of a dwelling and some acres of land—a cottage and cow, garth and hempland, so as to become passing rich on £40 a year. And it is doubtful if his father's handicraft had advanced his status beyond the possession of a cow and a cow's grassing until the death of his brother Jonathan—uncle to John. From the circumstance of John Dalton joining the rank and file of husbandmen, it may be inferred that his

> "Ambition did not mock their useful toil,"

and that he did not disregard their "homely joys." His disposition to farming may have been influenced by the fact of his Uncle Jonathan, then in the enjoyment of a few acres, being in the sixty-fifth year of his age, and without any probability of issue, and that the said uncle had noticed with favour the merits of his nephew, upon whose shoulders the burden of the day might soon fall. Moreover, an honest farmer, with a small yeoman's position in prospect, would be viewed quite as respectable, and much more profitable, than the grade of a country schoolmaster on the uplands of Cumberland. Thus circumstances might have thrown John Dalton into the position of a poor farmer, with aims no larger than selling corn and cows at Cockermouth market, instead of becoming a chemical philosopher honoured by the *savans* of Europe.

All biographical notices of John Dalton's assign to him yeoman's ancestry. This would appear to be a mistake, as the foregoing pages prove the artisanship of both his father and grandfather, and probably arose from the fact of Jonathan, the shoemaker, possessing a few acres of land through his own industry, or as the dowry of his wife Abigail, which eventually fell to John Dalton on the death of his brother, the schoolmaster at Kendal. In a statement of John Dalton's (hereafter to be noticed), complaining of the distribution of his father's property, there is no mention of any other possession of his father's than what had accrued to him as the successor of his brother Jonathan—uncle to the chemist. The only circumstance to lead to a contrary opinion is a mortgage of £150, or thereabouts, on the Eaglesfield property, and this may have been laid on by Joseph Dalton, the weaver, after his brother Jonathan's death, with the view of assisting his two sons in the establishment of a boarding-school at Kendal in 1786.

Whilst John Dalton was plodding away in his capacity of schoolmaster, or taking his honest share in husbandry operations, by which his bone and muscle got their truthful balance and vigour along with the development of his nerve-power, his brother Jonathan was acting as usher or assistant to his cousin, George Bewley, who kept a school at Kendal. It was probably owing to Mr Bewley's wish to retire that Jonathan Dalton held out to his brother John the desirability of leaving Eaglesfield and joining him, with a view to a school-partnership. Joseph and

Deborah, the parents, having taken counsel of "Friends," approved of the son's proposal; and in the summer or autumn of 1761, when he was about to complete his sixteenth year, John Dalton bade farewell as a resident to Eaglesfield.

CHAPTER III.

"For Nature's crescent does not grow alone,
In thews and bulk ; but, as this temple waxes,
The inward service of the mind and soul
Grows wide withal." —SHAKESPEARE.

KENDAL SCHOOL AND SOCIAL LIFE—LECTURES ON NATURAL PHILOSOPHY—MR GOUGH'S FRIENDSHIP—CONTRIBUTION TO "THE DIARIES"—INVESTIGATIONS OF ENGLISH SURNAMES.

IN anticipation of getting on in the world, and disposed to covet the latest novelty of a gentleman's outfit, John Dalton bought an umbrella—a curiosity of its kind a hundred years ago—at Cockermouth, and with this equipment in one hand, and a bundle of body-clothes in the other, started on his journey for Kendal, a distance of forty-four miles, which he accomplished in a day. This was his first break off from the home circle, and if his emotions at all responded to the natural scenery through which he passed, he may have framed for himself a sort of earthly paradise *en route*. Journeying through Cockermouth, and by the banks of the placid lake of Bassenthwaite, he soon came in view of Derwentwater in all its glorious beauty and surroundings, with the unrivalled peaks of Borrowdale beyond, each step revealing new features of picturesque hill and dale, grey homestead

and green meadow. Crossing Dunmail Raise showed him another sight, the attractions of which could not fail to lighten his descent to Grassmere, Rydal, and Windermere—"the queen," and fair daughters of the lakes—and to fill his mind with poetical fancy and unspeakable admiration. The mental enjoyment of such a day would bar all feeling of physical fatigue, and enable him to reach Kendal with a mind as buoyant and bright as the ethereal atmosphere floating o'er the mountain-tops of Skiddaw and Langdale Pikes.

As a boy in his early teens, travelling alone amid the indescribable loveliness of the lake country, and gazing at the flickering lights and shadows on the everlasting hills, he little conjectured the strange evolutions of the coming time—that a day of historical distinction was about to dawn over the scene of his journey, mainly owing to the genius of Wordsworth, the Coleridges, Southey, and De Quincey; and still less did he suppose that the meteorological characteristics of the district would some day become a theme of fertile interest to himself, the successful investigation of which would give him rank among the scientific discoverers of the age, and a niche in the pantheon of English celebrities.

Kendal, at the time of John Dalton's entry, had a population of 5000, and a flourishing wool and cotton trade, demanding hundreds of packhorses * to carry

* Before Dalton's time stage-waggons had partly displaced "packhorses," and a stage-coach—the "Flying Machine"—drawn by six horses, arrived twice a week from London; but it was 1786 before a mail-coach ran from London to Kendal. Though churches and schools were getting built, and a newsroom established, and much educational

its merchandise to the seaports—Liverpool chiefly. If its stalwart sons in native green had bravely fought and won on Flodden field, they were no less anxious in the Georgian era for the arts of peace and commercial life; they were men of enterprise, and the leading families of the town were Quakers, not wanting in culture and education.

John Dalton, looking at the motto on the arms of the Kendal Corporation—"*Pannus mihi panis*"—might be disposed to think if the staple produce of the town yielded bread to its working folk, the education of the lieges should go a step higher, and provide him with butter to that bread. Teaching the young ideas offered, however, no easy path to the comforts, much less the indulgences of life; indeed, no class of persons fared worse, considering their great merits, than the schoolmasters of England in the 18th century.

It was in the year 1781 that John Dalton joined his cousin George Bewley, who, with Jonathan Dalton as assistant, conducted a school for both sexes—mainly Quakers' children. On the retirement of Mr Bewley in 1785, the brothers Dalton announced their intention of continuing the school, "where youths will be carefully instructed in English, Latin, Greek, and French; also writing, arithmetic, merchants' accounts, and the mathematics." They also offered to take boarders on reasonable terms. Their sister Mary came from Eaglesfield to act as their housekeeper. At this time their pecuniary means were very limited, having occasionally to borrow two

progress was being made in the town, bull-baiting held its place till the year 1791, when it was suppressed by the Corporation.

or three pounds from Mr Bewley and other friends, as well as their own parents,* to enable them to carry on their small establishment. The earnings of the two brothers in the first year were about 100 guineas, and this sum was thirty guineas more than the average proceeds of some succeeding years. They made a little money by "drawing conditions," collecting rents, making wills, and other small commissions befitting the pen and ready-reckoning attributes of country schoolmasters; but it is doubtful if the two brothers conjointly, and by arduous labour, realised £100 a year, on which sum they had to supply their own and their sister's wants, and to appear in respectable costume, suited to the middle-class social position of Kendal.

A second circular, issued on July 5, 1786, by the Daltons, showed that they were not disposed to hide their talents under a bushel, and that their educational programme embraced almost all that could be taught in the highest public schools in the realm, seeing that it embraced what they had previously advertised, and nearly the whole range of subjects included under the heading of Natural Philosophy. The public were also informed that the Daltons would give private instruction in the use of the globes after school-hours; that they "could conveniently teach a considerable number of scholars more than at present;" and that parents might rely on their children being carefully instructed.

* Joseph and Deborah Dalton used to visit their sons and daughter at Kendal, carrying them Eaglesfield cakes and home produce, deeming the long day's journey of forty-four miles on foot a matter of minor consideration when the welfare of their family and their own parental joy could be promoted by the undertaking.

Whilst truly zealous in their calling of schoolmasters, the brothers Dalton were neither gainly nor genial in manner, and somewhat deficient in the art of winning the pleasant regards of their pupils. The bucolicism of Eaglesfield still clung to their nature, and manifested itself outwardly in their upright coat-collars, broad-brims, and an unbending fell-side Quakerism. As schoolmasters, they were severe disciplinarians, exacting silence, order, and a faithful adherence to prescribed rules: the gentlest prating of the little girls, or the smallest blot on a page of writing, called forth rebuke. Admonition was the fact of the hour, and if this did not suffice, the cane or "the tawse," consisting of short leather thongs, was applied to the palm of the hand, and in worse forms of punishment to the bare back. One instance of severity brought the Daltons rather prominently before the public, and led them to exercise greater caution in future in flagellating the worst offenders. Jonathan was looked upon as principal of the school, and was the severer taskmaster. John's more youthful sympathies saved him from so much juvenile reproach; yet my information, derived from their pupils, tends to show that he was far from conciliatory in method, or prone to educe the kindlier parts of his scholars. Their teaching was much more elementary than their curriculum of study, classics, and physics, indicated. It is said that in the midst of thirty or forty scholars, and all their noisy doings, John found minutes of leisure at his own desk to work out the higher mathematics; if so, he possessed a fifty-schoolmaster power of abstraction, along with a rare intensity of application.

With the dawn of manhood John Dalton would try his hand at public lecturing, and here is his programme issued to the Kendalites on October 26, 1787:—

"Twelve Lectures on Natural Philosophy, to be read at the school (if a sufficient number of subscribers are procured) by John Dalton. Subscribers to the whole, half a guinea; or one shilling for single nights. *N.B.*—Subscribers to the whole course will have the liberty of requiring further explanation of subjects that may not be sufficiently discussed or clearly perceived when under immediate consideration; also of proposing doubts, objections, &c.; all which will be illustrated and obviated at suitable times to be mentioned at the commencement." His syllabus included mechanics, optics, pneumatics, astronomy, and the use of the globes, and concluded with "*Ex rerum causis supremam noscere causam.*"

This course of lectures he repeated in 1791, with the addition of a lecture on Fire. As indicative of his first effort being less supported than it ought to have been, his terms of admittance to the second course were five shillings for the whole, or sixpence for each lecture; in other words, half the charge that he made in 1787. Dr Henry states that "it became a part of Dalton's regular occupations, and an important source of his slender revenues, to deliver lectures in Manchester and elsewhere." Repeated inquiries on my own part have failed to show his character as a public lecturer. His readiness to impart knowledge may be assumed, but how far his address and language and illustration were suited to a general audience at this period of his history admits of question. Moreover, his

inexperience in the art, no less than his early training, would offer no small drawback to his success and popularity.

His seven hours' tuition, and the needful victualling of the man himself, occupied the best part of his diurnal; his evenings not engaged in private instruction were given to classics, mathematics, and historical reading and the *Diaries*. There is nothing in his records or reasoning, as far as I can learn, to indicate large attainment in philology or classical literature. The former study engaged his thoughts for a time, as will presently be noted, but only within the range of an English tracing: nor could such accomplishments be expected in a man the bent of whose mind lay partly in the direction of natural history, and more largely towards the culture of the strictly physical sciences. Each day found him work to do, and ability and force to grasp what he undertook; it was work at school, work at home, and much cogitation everywhere.

John Dalton bore considerable affinity to Benjamin Franklin in mental vigour and bodily constitution, and specially in habits of industry and forethought; but the renowned American printer found hours of leisure, and could bestow a helping-hand towards the social and political amelioration of his fellow-citizens. Moreover, he entered with zest into the spirit of the times and the calls of society, thoroughly appreciated the smiles and favours of women, and all the amenities of life. Nor did his philosophy and patriotism suffer an iota by these deviations from the rigid lines of study and reflection, but probably gained much invigoration and lastingness, and gave him facili-

ties of intercourse with, as well as high rank among, the learned men of his epoch. The Cumbrian schoolmaster, on the other hand, would direct his nerve-force almost exclusively to purely intellectual aims, passing through his adolescence apparently indifferent to the *status quo* of governments and municipalities, and not much cognisant of the various relations of man to man—civil, commercial, and political.

During the first few years of his residence in Kendal his society was almost entirely confined to the guarded coterie of his own "regiment of drab"—a social circle possessing many good qualities of both head and heart, and not without its pretty white caps, rustling muslins, and personal charms, but more or less deficient in breadth of character, vivacity of deportment, and adaptation to the usages of the world. His probationary period on the banks of the Kent extended over twelve years, namely, from his early teens to the age of twenty-seven years, an important period in a man's life, when the body breathes full vitality and force, and the heart should be plastic and impressionable. His youth and growing adolescence showed lots of vigour and mental scope; yet his life comes down to us not betokening any signs of an active citizenship, but rather as the manifestation of an intellectual machine seldom beating time to the social or political impulses of a free and happy community like that of England. It may, however, be said in favour of this comparative seclusion from the fraternisations of the world, that high aims can only be grasped by continuous and concentrated efforts in one direction, and John Dalton's vocation lay in the interpretation of the abstruse,

and the methodising of science out of a careful study of natural phenomena. He was a student, and a hard-working one, all his days; the temptations of youth seem to have passed him by as one too sparingly emotional for the snares of life. Love, which a great poet said

"Rules the court, the camp, the grove,"

seemed to find no favour in Dalton's eyes, even at a time when, if ever, the feelings are warm and prone to be waylaid by the blandishments of the fair. His eyes, it is true, were peculiarly affected, and could not be gladdened by the roseate hue of woman's cheeks, or the ribbon adornments and other coloured media displayed as attractions indigenous to the sex.

John Dalton's studious character, and solicitations for advancement beyond the sphere of common mortals, as evinced by his public lectures, would suffice for an introduction to Mr John Gough, the intellectual man of Kendal, and the pleasant friendship that sprung up from this intercourse, was the third piece of good luck falling in the way of the poor weaver's son, the tuition of John Fletcher and the guiding counsel of Elihu Robinson, constituting the two first props to his well-doing in the world. Though blind from early infancy, Mr Gough was a person of rare accomplishments, whose fertile mind travelled over a large field of science, and whose character was well-known to some of the leading minds in the north of England. It is difficult to estimate the amount of good derived by Dalton from a man of such ripe judgment and intellectual grasp as Mr Gough, who could be no ordinary person to gain the following tribute from Wordsworth the poet:—

> "Methinks I see him now, his eyeballs roll'd
> Beneath his ample brow—in darkness pained,
> But each instinct with spirit, and the frame
> Of the whole countenance alive with thought,
> Fancy, and understanding, whilst the voice
> Discoursed of natural or moral truth
> With eloquence and such authentic power,
> That in his presence humbler knowledge stood
> Abashed, and tender pity overawed."

A letter of Dalton's to Mr Peter Crosthwaite, of Keswick, shows his opinion of his friend Mr Gough :—

"John Gough is the son of a wealthy tradesman in this town; unfortunately he lost his sight by the small-pox when about two years old, since which he has been quite blind, and may now be about thirty. He is perhaps one of the most astonishing instances that ever appeared of what genius, united with perseverance and every other subsidiary aid, can accomplish when deprived of what we usually reckon the most valuable sense. He is a perfect master of the Latin, Greek, and French tongues, the former of which I knew nothing of six years ago, when I first came here from my native place near Cockermouth, but under his tuition have since acquired a good knowledge of them. He understands well all the different branches of mathematics, and it is wonderful what difficult and abstruse problems he will solve in his own head. There is no branch of natural philosophy but what he is well acquainted with; he knows by the touch, taste, and smell almost every plant within twenty miles of this place; he can reason with astonishing perspicuity on the construction of the eye, the nature of light and colours, and of optic glasses; he is a good proficient in astronomy, chemistry, medicine, &c., &c. He and

I have been for a long time very intimate; as our pursuits are common, viz., mathematical and philosophical, we find it very agreeable frequently to communicate our sentiments to each other, and to converse on those topics."

In his preface to his "Meteorological Observations and Essays," published in 1834, Dalton expresses his obligations to Mr Gough in the following words:—

"For about eight years during my residence in Kendal we were intimately acquainted. Mr Gough was as much gratified with imparting his stores of science as I was in receiving them. My use to him was chiefly in reading, writing, and making calculations and diagrams, and in participating with him in the pleasure resulting from successful investigations; but as Mr Gough was above receiving any pecuniary recompense, the balance of advantage was greatly in my favour, and I am glad to have this opportunity of acknowledging it. It was he who first set the example of keeping a meteorological journal at Kendal."

"During this period," writes Dr Henry, "he contributed frequently to two periodical works then in considerable repute, the *Gentleman's and Ladies' Diary*. The volumes from 1784 to 1794 contain many solutions of questions in mathematics or general philosophy to which his name is attached. He obtained two of the prizes awarded by the editors."

Quoting from "An Account of the Early Mathematical and Philosophical Writings of the late Dr Dalton," by Mr T. T. Wilkinson, F.R.A.S., of Burnley, Dr Henry continues his remarks on the *Diaries*, and Dalton's contributions. "The selection of questions for the year 1787 embraced nearly all the branches

of mathematics then cultivated by English geometers; and yet he correctly solved thirteen out of the list of fifteen, the prize question included. His solution of question 850 is inserted at length in the *Diary*, and is probably the earliest printed specimen of his mathematical writings. He was equally successful in the following year, 1788, and from his replies to questions in general philosophy, appears to have already bestowed some attention on chemistry, and to be conversant with some French writers on that science. Mechanics and fluxions had also engaged his attention. On the appearance of the *Ladies'** *Diary* for 1789, Mr Dalton must have felt himself amply rewarded for all his previous disappointments; for, besides obtaining insertion of his answers to *all* the philosophical queries, and to *three* out of *eleven* solutions sent to the questions in the mathematical department, he was awarded the "prize of six diaries." In the *Gentleman's Diary* for the same year his name is announced as having furnished correct solutions to seven of the mathematical questions, of which that to question 591, relating to a case of hydrostatical equilibrium, is inserted at length, and gained him his first position amongst the correspondents to that noted and difficult serial. The *Ladies' Diary* and supplement for 1790 conveyed the gratifying intelligence, that he had been awarded the highest prize of ten diaries for his masterly solution of the prize question."

A few extracts from the *Ladies' Diary*, containing some queries and solutions by Dalton on questions

* The *Ladies' Diary* is said to have been conducted by Dr C. Hutton, of the Royal Military Academy.

apparently incongruous with his usual studies may interest the reader; they were furnished by my late friend Dr George Wilson of Edinburgh to Dr Henry of Manchester.

QUERY 1.—Whether, to a generous mind, is the conferring or receiving an obligation the greater pleasure?

Answered by John Dalton as follows:—

The pleasure arising from conferring an obligation, especially if it be effected without much inconvenience, is pure, and must be a grateful sensation to a generous mind; but that arising from receiving an obligation is often mixed with the unpleasing reflection of inability to remunerate the benefactor. It is pretty clear, therefore, that the pleasure of conferring an obligation must exceed that of receiving one.

QUERY 2.—Is it possible for a person of sensibility and virtue, who has once felt the passion of love in the fullest extent that the human heart is capable of receiving it (being by death, or some other circumstance, for ever deprived of the object of its wishes), ever to feel an equal passion for any other object?

Answered by John Dalton as follows:—

It will be generally allowed that in sustaining the disappointments incident to life, true fortitude would guard us from the extremes of insuperable melancholy and stoic insensibility, both being incompatible with your own happiness and the good of mankind. If, therefore, the passion of love have not acquired too great an ascendency over the reason, we may, I think, conclude that true magnanimity may support the shock without eventually feeling the mental powers and affections enervated and destroyed by it, and consequently that the query may be answered in the affirmative. However, if this passion be too strong, when compared with the other faculties of the mind, it may be feared that the shock will enfeeble it, so as to render the exercise of its functions in future much more limited than before.

The following letter of Dalton's to his friend

William Alderson of Eaglesfield, shows a new walk of study, and is highly characteristic of the writer :—

"KENDAL, 8 *mo.*, *4th*, 1788.

"RESPECTED FRIEND,—Happening a while ago to be in company where the topic of conversation was the derivation of surnames, a subject quite new to me, and being, as thou may remember, inquisitive into things seemingly involved in mystery, and which require some sagacity to unravel, I could not help afterwards reflecting a little upon it. The substance of my reflections, and the information I could get being put to paper, will run nearly as follows. There is very little utility arising from the subject, but a small matter of curiosity, which I thought might not be altogether unacceptable.

"Anciently in this kingdom it seems to have been customary to have only one name, that is, what is now called the Christian name; and that not being sufficient for distinction, others were added to it, such as were most fit to answer that end, such as whose son a person was, what trade he was, where he came from, &c., which, however, were subject to change, according to the caprice of the neighbourhood or fancy of the person, till the Legislature found it necessary that they should be fixed, to prevent the evils that might otherwise arise.

"INVESTIGATION OF ENGLISH SURNAMES.

"1st. Of those ending in -SON.

"We have a large tribe of these from Christian or first names, such as John, Jack, Harry, Dick, Richard, William, Will, Tom, Robin, Robert, Ben, Allen, &c.—

that is, the father being called John, his son was called John's-son, or Johnson, &c.

"Also diminutives of some of these; as Dickin, Wilkin, Tomlin, Jenkin, &c. -son; that is, little Dick's son, &c.

"A few, probably bastards from women's names; as Ann, Elly, Matty, Nel, Patty, &c. -son.

"Some from other surnames; as Cook, Smith, Hodge, Dodge, Dod, Dob, Hood, &c. -son.

"2d. Another custom seems to have obtained in the south part of the kingdom, that is, using the genitive case of the father's name instead of the word 'son' at the end of it; thus we there meet with Stephens, Roberts, Philips, Edwards, Harrys or Harris, Jones (that is, Joan's or John's), &c., which in the north are more commonly Stephenson, Robertson, &c.

"From this it may be suspected the Harris families in the north were originally from the south, otherwise they would most likely have been called Harrisons.

"3d. Another source of surnames we have from ancient and trading towns; as York, Chester, Lancaster, Kendal, Carlisle, Derby, Wakefield, &c. Thus an inhabitant of Kendal called Tom, removing to a distant place, would be called Kendal Tom, to distinguish him from the other Toms of the place. Besides these, a great number from places of less note ending in *ton* (*i.e.*, town), *thwaite* (a place cleared of wood); as Braithwaite, Cros-thwaite, Lew-thwaite; Dal-ton (a village in Lancashire meaning Dale-town), New-ton, Pennington, Pockling-ton, Nor-ton, Wes-ton, &c. To these may be added a few from the names of nations; as

Scot, English, Ireland, French, Norman (*i.e.*, a follower of William the Conqueror from Normandy), Wales, &c.

"Also a number derived from the situation of their dwellings; as Fell, Gill, How, Hill, Bank, Bottom, Beck, Brook, Wall, Penn (*i.e.*, Hill), Mount, Slack, Cragg, Moor, Moss, Tarn, Pit, &c.

"4th. A vast number from trades, &c.; as Smith, Wright, Weaver, Webster, Waller, Mason, Fisher, Hunter, Fiddler, Piper, Harper, Walker, Cleaver, Slater, Sadler, Herd, Cook, Clark, Steward, Butler, Baker, Brewer, Gardener, Roper, Fletcher (one that makes bows and arrows), Glover, Barber, Ridler, Stamper, Shepherd, Turner, Forster (*i.e.*, Forester), &c. Also from articles, &c., dealt in; as Hay, Stone, Steele, Bell, Wood, Peat, Lindsey, Wolsey, Cotton, &c.

"5th. From animals; as Fox, Tod (an old word for a fox), Stag, Hinde, Kid, Lamb, Drake, Duck, Cock, Peacock, Salmon, Pike, Trout, &c.

"6th. Some adjectives; as Black, Blake, Dun, White, Brown, Green, Grey, Petty, Wild, Swift, Smart, Sharp, Wise, Young, &c.

"7th. A few ending in *man;* as Bulman, Cow-man, Bow-man, Chap-man, Priest-man, Spel-man, Woolman, &c. Also several in *ley;* as Ains-ley, Bay-ley, Bew-ley, Brink-ley, Cow-ley, Hors-ley, Chalk-ley, Hay-ley, Hart-ley, Priest-ley, &c. *Ley* is an old word for scythe, also for ploughed land now resting for the scythe.

"8th. Compound names of pretty obvious origin; as Brock-bank, Sow-den, Lang-mire, Mire-house, Waterhouse, Salt-house, Cross-field, Swin-burn, Burn-yeat

(N.B. *Bourn* is Saxon, meaning a brook), Black-stock, Light-foot, Young-husband, Tod-hunter, Drink-water, &c.

"I might pursue the subject farther, as also of the origin of the names of places, &c., but I leave it to antiquarians.

"However, as I have explained my own name, I must do the same with thine. Alderson means undoubtedly older-son, old being pronounced ald in this county, where possibly the name originated; but it is not easily made appear how such a name rose.—Please to accept the best respects of thy friend,

"JOHN DALTON.

"WILLIAM ALDERSON,
Eaglesfield."

CHAPTER IV.

"*Nature is not an inert mass; and to him who can comprehend her vast sublimity, she reveals herself as the creative force of the universe—before all time, eternal, ever active, she calls to life all things, whether perishable or imperishable.*"—SCHELLING.

NATURAL HISTORY PURSUITS—METEOROLOGICAL LABOURS AND CORRESPONDENCE — BOTANY — ENTOMOLOGY — STUDY OF MAN AND THAT OF MEDICINE CONTEMPLATED—HIS FATHER'S WILL IN DISPUTE, AND NOVEL ARBITRATION—LEAVES KENDAL FOR MANCHESTER.

IN his hours of comparative relaxation, John Dalton took his constitutional walk, and on Saturdays extended his rambles o'er the country side; admiring the grand panorama—the sweeping outline of mountain range and fertile valleys in the environs of Kendal; and meditating much on the geognosy of the district, its fauna, flora, and natural history in general. Like Goethe, Alexander von Humboldt, and others who paved their way to distinction by researches in the domain of natural science, Dalton early engaged in the study of botany, entomology, and more especially meteorology. The friendship of Mr Gough naturally exercised a beneficial influence over Dalton's scientific endeavours. In that day when Buffon, Goldsmith, and peripatetic herbalists held sway as naturalists, and Linnæus was only to be found in the hands of the learned, it is doubtful if any other library than that of the blind philosopher of Kendal was accessible

to him, from which he could even cull a knowledge of the descriptive forms of plants and the common kinds of insects. And this kind of information, little more than a systematic nomenclature in the hands of the renowned Swede, was but elementary and limited in scope compared with the needs of a true science. As far as the study of meteorology was concerned, Dalton could have no better guide than Mr Gough himself.

Dalton's love of nature did not find expression in the sentimental language of Rousseau; it was neither exalted nor demonstrative, and probably owed less to his emotional or pleasurable instincts than to his innate scientific ardour, ever aiming at the grasp of the unproclaimed and the unknown. Imbued with the faculty of originating fresh paths of inquiry, and possessing a genetic force to cope with difficulties whencesoever arising, he would seem to have anticipated Schelling's observation, that philosophy advances not so much by the answers to difficult problems, as by the starting of new problems, and by asking questions which no one else would think of asking.

In his endeavours to elucidate the phenomena included under the general term of meteorology—phenomena so fitful and protean in character on the shores of England, and markedly pluviose around Kendal —he fell upon an inquiry consonant with his untiring industry and careful methods of observation. The subject, comprehensive in itself, also involved many questions which had never been asked, and as many more equally worthy of solution. Meteorology had an historical basis as old as Aristotle himself, and though the theme of many minds in many countries, yet so little progress had been obtained since the

days of the Greek naturalist, that it presented almost a new field for John Dalton's patient investigation. Observation and observations ever repeated were, from the very nature of the elements in operation, essential to unravel the phenomena grouped under the subject-matter of the weather, the seasons, and climate; and these, again, had to be viewed under the modifying influence of heat, electricity, and more strictly astronomical causes. The general laws of physics and chemistry, and due recognition of the researches of Galileo, Torricelli, and Newton, formed an instructive basis upon which future labourers in the field must rest their lines of inquiry. All this would be patent to Dalton, and the encountering of difficulties at the very threshold would really offer the largest inducement to him to persevere in the pursuit. As the thermometer, barometer, and rain-gauge were the first requirements in the physical investigation of meteorology, he thought the best way of knowing how to use them, was to know how to construct them *ab initio ad finem.* Besides, philosophical instruments of all kinds were exceedingly scarce and dear in the north of England; and John's pecuniary means were not commensurate with any extraordinary outlay.

As Dalton's meteorological labours will be more appropriately discussed in the next chapter, all that is needful here is to trace the beginning of his work, and to show by his letters how his enthusiasm led him to try and indoctrinate others with the same scientific penchant. From personal inquiry I am led to infer that Dalton's first meteorological observations were made in the year 1787–88; and this is confirmed, or

rather more clearly set forth, by Dr Henry, who reports that he found among his friend's papers a small quarto volume entitled "Philosophical Memoirs, begun at Kendal, 1787; auctore, Johanne Dalton;" and that it was "loosely attached to two similar books, which carry down the history of his inquiries to 1801." This journal records little of interest between June 1787 and the end of the year, except the measurement of some hills near Kendal by means of the barometer. The year 1788 commences with a "memorandum of the going of two hygrometers, or pieces of whipcord, each being eight feet five inches long, stretched by equal weights, and similarly situated along an oaken post in the school, where was no fire." These experiments are followed by a table of times when the *auroræ boreales* have been seen, together with the moon's age at the several times.

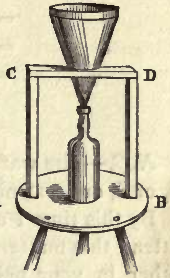
Subjoined is a letter to Miss Hudson, one of his Eaglesfield pupils, couched in terms to imply that Cumberland villages had young women of education capable of grasping decimals and the use of a scientific instrument. The letter is given *in extenso*, to show his mode of rain-gauge and calculations:—

KENDAL, 8 *mo.*, 4*th*, 1788.

RESPECTED FRIEND,—The study of Nature having been with me a predominant inclination, it is not unlikely that I should be ready to prompt others to the same. I have been tempted to think that thou would take a pleasure in remarking the quantity of rain that falls with you each day, if thou knew with what facility the same is effected. I have observed here that people who are entirely ignorant of the matter suppose it a work of great labour and difficulty, and which can only be done by those they call great scholars. This, however, is a great mistake. A very little knowledge of mensuration is sufficient

for the theory of it, and nothing but plain addition is wanted in the practice.

The annexed scheme will represent the most simple apparatus: A B is a three-foot stool, to be fixed in a garden bed, &c. A C and B D two posts fixed in the same about 11 or 12 inches, and support the arm C D, which is 1½ inch broad and 1 deep; the pipe of the funnel exactly fits the hole in C D, keeping the funnel firm and level. The funnel may be 6, 7, or more inches over; and if it have an upright rim of an inch, it is better, but will do without it. Also, it should be painted to save it from the weather. A common glass bottle will hold all the water that falls at any time in 24 hours, if the funnel be on only 6 or 7 inches diameter; except, perhaps, two or three days in the year. A pair of scales, with a few small weights, are requisite.



Now, to determine the depth of water that falls on any level surface from the above, we have the following tables made for funnels of 6 and 7 inches, wherein are set down the depths, corresponding to the several weights, in decimal fractions. And any person who has learned mensuration will be able to adapt a table to any funnel, by knowing that 62½ lbs. Avoirdupois equal 1 cubic foot of water.

Weights.	Diameters of Funnels.	
lb. Av.	6 inches.	7 inches.
1	·9778	·7184
oz. 8	·4889	·3592
4	·2445	·1796
2	·1222	·0898
1	·0611	·0449
drs. 8	·0306	·0225
4	·0153	·0112
2	·0076	·0056
1	·0038	·0028
½	·0019	·0014
¼	·0010	·0007
⅛	·0005	·0004

Suppose there is caught with a funnel of 6 inches diameter 1 lb. 3 oz. 5¼ drs. of water, required the depth.

1 lb.	=	·9778
2 oz.	=	·1222
1	=	·0611
4 drs.	=	·0153
1	=	·0038
¼	=	·0010
		1·1812

That is, the depth that would have fallen on a level surface

will be 1 inch, 1 tenth, 8 hundreds, 1 thousand, and 2 ten thousand parts of an inch.

Suppose with a funnel of 7 inches there is caught 1 oz. 7½ drs.

1 oz.	=	·0449	
4 drs.	=	·0112	
2	=	·0056	That is, 6 hundredth, 5 ten
1	=	·0028	hundredth or thousandth, 9 ten
½	=	·0014	thousandth parts of an inch.
		·0659	

N.B.—The water is supposed to be taken at stated hours, as 6, or 8, or 10 at night.

By this time I apprehend the difficulty generally supposed to attend this matter is removed. I should be glad if thou, or any other in your neighbourhood, on whose accuracy one might rely, would find it agreeable and convenient to notice this matter; but, however, I do not mean to request it, but only to show the easiness with which it's done. Ignorance, no doubt, will look upon this as a trifling and childish amusement, but few of this nature are such in a philosophical sense. If to be able to predict the state of the weather, with tolerable precision, by which great advantages might accrue to the husbandman, to the mariner, and to mankind in general, be at all an object worthy of pursuit, that person who has in any manner contributed to attain it cannot be said to have lived or to have laboured in vain.*—I am respectfully, thy friend, JOHN DALTON.

To SARAH HUDSON,
Eaglesfield.

Dalton's mode of making thermometers is described in the following letter to Elihu Robinson. In presenting these instruments to those who befriended his early youth, he proved his gratitude for past favours, no less than a wish to see the struggling science of meteorology promoted by men of real capacity and worth.

* The caligraphy of this and the following letter is nearly as perfect as the work of the engraver.

KENDAL, 8 *mo.* 23*d*, 1788.

DEAR COUSIN,—Herewith thou wilt receive, I hope safely, two thermometers with somewhat longer scales than the former; please to take thy choice of the three, to let John Fletcher have the next choice, and to reserve the other till my brother comes.

You will probably chuse by the length of the scales; but those with the least bulbs will soonest come to the temperature of the surrounding medium. However, the largest, I apprehend, will rise or fall to within a degree of the proper place in half an hour in the air. Thou may try whether that thou hast already is with these two or not, by dipping the bulbs into a bason of water for five minutes.

Possibly the manner of making them may not be unentertaining. A small receptacle being fixed on the end of the tube, a quantity of mercury is poured into it, part of which runs down the tube so as to half fill the bulb, and then stops, the tube being still filled with mercury, which is unable to fall by reason of the pressure of the air in the bulb. Then a candle is applied to the bulb, which, rarefying the air contained in it, raises the mercury in the tube quickly to the top, and then it escapes in bubbles through the mercury in the receptacle. This done, it is cooled again, when the internal air contracting, another portion of mercury falls down into the bulb; and this operation is repeated till all the air is expelled. Then the mercury is heated above boiling water, and the end of the tube melted and closed at the same time, when, the mercury subsiding, there is left a vacuum; this is done chiefly to keep the moisture, dust, &c., out of the tube. The whole is then put into boiling water, when the barometer stands at 30 inches, and the boiling point thereby determined; afterwards (if circumstances admit) the freezing point is found by putting it into a mixture of water and pounded ice, or water and snow, which, when melting before the fire, keep at an invariable point (32°) till the whole is melted. If this cannot be done, as in summer, it may be set by another thermometer, and the scale adapted accordingly. *N.B.*—As the freezing points of these two were not found on account of the season, it will not be amiss to try whether they are accurate, when a convenient season comes.

The principles on which they act need little explication; as mercury, like most other bodies, is subject to be contracted by cold and expanded by heat; and as the capacity of the bulb remains always filled, the total variation of the mercury in bulk, it is evident, will be manifested in the tube.

The range of the thermometer is little in these parts compared with the more northern. At Petersburgh the summer heat is equal to ours, but in winter severe cold predominates; the thermometer is frequently found 40 or 60 below nothing; and in Siberia it has been observed even 100 or 120 below nothing. On the contrary, in the burning sands of Africa it reaches 120 or 140 above nothing. Is not the internal principle of heat in man and other animals a wonderful phenomenon, that can sustain these two extremes without any sensible variation? Remark.—Réaumur's scale (used by the French and others) counts from 0 at the freezing point to 80 at the boiling point; consequently $2\frac{1}{4}$ degrees Fahrenheit are equal to 1 of Réaumur.

ABSTRACT OF MY JOURNAL FOR THE PRESENT YEAR.

Thermometer without.				Rain. Inches and Decimals.	Wet Days.	Auroræ Boreales.
	Mean.	Highest.	Lowest.			
1 mo.	39·	47	20	5·6160	20	6
2 mo.	38·3	47	28	3·3064	23	2
3 mo.	36·8	50	18	2·8183	16	4
4 mo.	46·3	69	32	2·9047	16	11
5 mo.	53·	80	38	1·1872	10	7
6 mo.	57·3	80	45	2·3137	7	2
7 mo.	56·8	68	47	7·0323	28	1

THUNDER-STORMS.

5 mo., 19. 2 P.M., distant, W.

" 26. 7 P.M., frequent loud peals, very near.

7 mo., 3. 6 P.M., frequent peals, some very near.

8 mo., 16. $7\frac{1}{2}$ P.M., distant about 8 miles S.E., but loud and tremendous; about 20 or 30 flashes were observed in as many minutes, and the reports of each heard through the cloud, was but just visible above the horizon; the zenith clear.—My love to Cousin Ruth, self, and family, JOHN DALTON.

Dr Henry, who had access to a series of letters written by Dalton to Mr Peter Crosthwaite of Keswick in the year 1787–94, relating almost entirely to meteorological observations made simultaneously by the two friends at their respective stations, Kendal and Keswick, for the purpose of comparison, informs his readers that "Dalton supplied Mr Crosthwaite with a barometer and thermometer of his own construction, for which he charged the modest sums of eighteen shillings and five shillings. It is true that the barometer was not a very refined instrument, for in a letter to Mr Crosthwaite, May 24, 1788, he describes minutely the mode of its construction. It is obvious, that as he omits to boil or even heat the mercury after it is poured into the tube, both air and moisture must remain attached to the tube, and mingled with the mercury. This imperfection he seems to have discovered, for he writes soon afterwards: 'I intend to renew mine as soon as convenient; if thou do the same, be careful in undoing it, and attend to the cautions I give. Be sure to rub the inside of the tube well with warm dry cotton or wool; and have the mercury, when poured in, at least milk-warm; for moisture is above all things else to be avoided, as it depresses the mercury far more than a particle of air does: mine is, as I have said, at least $\frac{1}{16}$th of an inch too low, and yet it is clear of air, and to all appearances dry; but I doubt not but attending to these precautions, *which I knew nothing of when it was filled,* will raise it up to its proper height.' Again, in January 1793, he observes: I consider both our barometers as inaccurate with respect to the distance of the *basins and scales;* but this is of little importance,

provided they be true in other respects; this only serves to show the relative heights of the places to the sea, which we can come at better by other means.' "

Botany also came in for a share of his correspondence, and I am again indebted to Dr Henry's quotations from the Crosthwaite series of letters :—

"Dalton informs Mr Crosthwaite that he had 'dried and pressed a good many plants, and pasted them down to sheets of white paper, and found that they look very pretty, and attract the attention of all, both learned and unlearned; this has induced me to think that a tolerable collection of them, treated in this manner, would be a very proper object in the museum. I cannot say what kind of recompense would be equivalent to such a task, but think I could engage to fill a book of two quires for half-a-guinea.' He afterwards writes, October 4, 1791: 'I have at length completed the book of plants, and made an index both to the Linnæan and English names. I am not so confident in my abilities as to maintain that I have given no plant a wrong name, but I believe the skilful botanist will find very few, if any, miscalled.' Mr Isaac Braithwaite remembers, that once when Dalton was botanising with a companion, 'they had a narrow escape from a bull that attacked them in a field; Dalton saved himself by climbing into a tree, or over the wall.' "

Dalton's classification of the Kendal flora extended no further than the lines of systematic botany. There was little more to be gained at the time, for owing to the neglect of the older authors, such as Malpighi, structural botany was little cultivated; and till the advent of Humboldt and Bonpland, geographical

botany, so full of general interest, had scarcely been heard of in England. In short, a true botany had as yet no place among the sciences, and Dalton, like others of his day, were busy collecting and learning the names of plants without any clear insight into the deeper meanings of phytology.

His herbarium or collection of specimens of plants around Kendal is preserved in the Public Free Library of Manchester. According to Dr Angus Smith, Mr T. P. Heywood of the Isle of Man has eleven volumes of Dalton's *Hortus siccus.* The first is a thick volume, containing the general title-page, "*Hortus siccus, seu Plantarum diversarum in Agris Kendal vicinis sponte nascentium Specimina, Opere et studio Johannis Dalton collecta, et secundum Classes et Ordines disposita.* 1790."

With a mind ever on the alert for novelty of study and treatment, the insect tribe came under his surveillance, along with botanical forms. Some of the butterflies he caught and prepared found their way to Mr Crosthwaite's museum at Keswick ; other specimens and groups of various entomological genera got scattered among his friends, and were lost sight of —probably owing to their imperfect preparation or preservation.

It would appear that Dalton was occasionally occupied in the years 1787-89 with observations on the changes of caterpillars, and on the power of a vacuum or immersion in water to destroy or suspend vitality in snails, mites, and maggots. In sending to his correspondent, Mr Crosthwaite, specimens of butterflies and ichneumon flies for the museum, he observed, "They may perhaps be deemed puerile,

but nothing that enjoys animal life, or that vegetates, is beneath the dignity of a naturalist to examine."

His collecting of insects, and his physiological experiments on mites and maggots just referred to, came to the ears of the public, and created some talk and curiosity, if not distinct disapproval. The traditions of sorcery, and the beliefs in

> "Adder's fork * and blind-worm's sting
> . . . .
> For a charm of powerful trouble,"

still slumbered along the mountain-sides, and superstition, in all its hydra-headed forms, lent wings to the imagination of the unlettered class; so that insinuations, promoted by the twisting influence of an enemy, might have proved damaging to John Dalton's more humane reputation. His studious habit and Quaker's garb, and probably the idea of his being an "herbalist and half doctor," that attributed his snail-gathering to a medical purpose, saved him from the declamation of gossiping women.

Inasmuch as he had a marked deficiency in the perception of colours, it would not be the attractive rainbow-coloured wings of the butterfly hanging over lovely roses, or the emerald coat of the beetle shining amid the dusky moss; nor the beauteous world of light, and the radiance of colours and shapes spread around—

> "In air, in water, and on earth,
> A thousand gems were struggling forth"—

that captivated his entomological zeal. His choice seems rather to have been determined by a love of

* "Adder's wisdom I have learned,
To fence my ears against thy sorceries."—MILTON.

knowledge for its own sake, and a wish to embrace the study of animated nature within his expansive sphere of observation. These natural history pursuits were a happy relief to his scholastic calling; they offered fresh fields and pastures new, correcting his more dry-as-dust studies, and giving him higher and healthier views of the outer world. The beetle and the butterfly would in time be viewed by Dalton not as individual species only to be examined *per se*, but as types and illustrations of generic form; and these again as but minor links in the great and apparently endless chain of organic life. Advancing onwards from this initiative step, the larger scheme of organisation would force itself upon his attention, and, as a corollary, the workings of the human machine, the investigation of which proved a large incentive to his study of the structure and physiology of man.

As he had no knowledge of the anatomy or groundwork of man's physical nature, Dalton fell upon a plan of his own to ascertain the mode of building up and sustentation of the human frame, and the metamorphoses which the solids and fluids of nutriment undergo in the digestive and respiratory processes of the economy. His method of inquiry, if crude, rested its evidence on the application of the balance, and so far claimed the consideration of accuracy. It consisted in his daily weighing his own ingesta and egesta, including, of course, the perspiration, in the hope of discovering man's positive wants as an animal; the quantity of food and drink essential to healthy life; and the mode in which nature disposed of the excretory and effete matters of the body. However curious and apparently foreign to all but the strictly pro-

fessional class such an investigation will appear, it is strongly indicative of Dalton's love of research, and of the deep interest he took in the laws of vitality affecting man's constitution.

This new experimental investigation, far from agreeable in pursuit, usurped his attention for some time, and gave a new direction to his thoughts of the future. If the proper study of mankind be man, why pursue laborious teaching, that saddens the patience rather than improves the intellect, when the laws of physiology await elucidation, and the pathological conditions of man demand his best energies and skill to overcome? Such thoughts evidently possessed Dalton when he wrote the following letter to Elihu Robinson, soliciting his opinion on a change of profession—that of medicine being most to his mind, and evidently springing from the pursuits just noticed:—

KENDAL, 4 *mo.*, 8*th*, 1790.

DEAR COUSIN,—The occasion of my addressing thee at this time is a projected change of my occupation, which I have been meditating on for some time past, in which thy countenance or disapprobation cannot fail of having due weight.

I have but one objection to my present business, which, however, is a very material one, and a very rational one; that is, the emoluments attending it are not sufficient to support a small family with the decency and reputation I could wish, should it fall to my lot to have it to do. As to the making of a fortune by it, that is entirely out of the question. I much doubt whether there is one person in the kingdom (amongst friends, I mean) who has, after a laborious life, reached independence by it. Indeed, very few people of a middling genius, or capacity for other business, will be found willing to undertake it, for the obvious reason assigned above.

I hope thou wilt not impute the above sentiments to the momentary chagrin of some disappointment, or to the gloom of a

declining school, as neither of these causes exist in any degree; they are the result of mature consideration and unbiassed judgment.

Thou wilt next expect I should signify what way my inclination has led me, as I may now be presumed capable of judging for myself, after having reviewed the vast variety of trades, arts, sciences, and professions with which the country abounds. Though I doubt not but my inclination would yet adapt itself to any business that promised to be of advantage, yet it seems most natural to turn to such wherein literary or scientific knowledge is requisite, as my pursuits and acquisitions hitherto have been chiefly of this nature. At the head of these stand law and physic. Whether of these professions would be more likely for me to make a livelihood, or whether would require more time and expense to attain, I cannot tell; but, interest being set aside, I should much prefer the latter.

The great objections are the expense at first, and the uncertainty of getting business afterward; but these, though great, I think, are not insurmountable. To qualify for a physician, three winters' study at Edinburgh will be indispensable; the board for six months may perhaps be had for £10 or £15, and the college fees will be about 12 guineas each season: the two intermediate summers may be employed in some sort of business, which will render the plan as frugal as possible. Now, putting the case at the worst, that I spend most or all of my effects in this scheme, and cannot succeed at last, I may then return to my present employ, as places are frequently vacant nearly as profitable as this.

Upon the whole the plan does not appear to me chimerical, and I should be glad to know thy sentiments upon it, at or before the time of the ensuing meeting at Lancaster. I have not yet acquainted friends here with it. Please also to inform us how and where my mother is. Our quarterly meeting is on the 18 and 19 instant.

Were I disposed to amuse thee a little, I might add some experiments I have lately made to determine the quantity of matter discharged from the body daily by insensible perspiration, &c., which I made for two weeks successively; and other particulars, as that I have practised as a quack for some time

past with good success; but further of these some other opportunity.

I hope this will find you all well, as it leaves us, and am thy affectionate cousin, JOHN DALTON.

To ELIHU ROBINSON,
Eaglesfield,
near Cockermouth.

Mr Robinson's reply intimated his wish to see Dalton continue in his own groove of schoolmaster, as being suited to his talents, which would "not only shine, but be really useful in that noble labour of teaching youth." Lest he should run counter to any settled opinions of his friend, he continues: "Now, after using so much freedom, I may own, I doubt not but thy genius, unshaken perseverance, and steady application may gain a competent knowledge in any profession, and I am far from thinking that of physic would be a misconstruction or misapplication of thy talents, parts, or genius. So I much desire thou mayest be guided *by best wisdom* in all thy pursuits."

He also consulted his uncle, Thomas Greenup, then in London, on the subject, and cannot be said to have obtained much encouragement. Thus wrote Mr Greenup: "As to the two professions of law and physic, if thou wishest to be at the head of one of those professions—that is, to be at the bar or to be a physician—I think they are both totally out of the reach of a person in thy circumstances. . . . If thou art tired of being a teacher, and wishest to change it for some more lucrative or agreeable employment, and couldst be content, instead of becoming a physician or barrister, to move in the humbler sphere of apothecary or attorney, thou mightest,

perhaps, be able, with a little capital and great industry, to establish thyself in one of these."

Here it becomes necessary to notice a family dispute of the brothers Dalton, arising out of their father's will, where John, the younger son, was the complainant. Joseph Dalton died in 1787, leaving a widow, an only daughter, and two sons. In the disposal of his affairs he seems to have laboured under the belief that the property which came to him on his brother Jonathan's death was an entail of their father's, and that he could not meddle with it, and that it must necessarily fall to his oldest son, Jonathan. John Dalton, on the other hand, felt sure that his father wished to make no distinction between his two sons, and argued for a more equal distribution of his father's effects. John did not think of applying to a court of law—there, indeed, he would have been nonsuited—but, in the spirit of George Fox and what may be termed a high moral equity, solicited the mediation of the Friends' monthly meeting on his behalf. This mode of procedure cannot fail to strike the reader as a denominational novelty of a startling kind, and so it is. And though seldom brought to bear upon testamentary matters, such a court of arbitration, consisting of two or more members — the chiefs and elders of Quakerism — is a happy exemplification of their peaceful attitude as a religious body, and their laudable wish not only to avoid the meshes of the law, but so to counsel the brethren that they may live in amity and peace. In the instance before us the good purposes of the arbitration, however the decision was made, was best demonstrated in the fact that Jonathan and John Dalton continued in brotherly

affection—a circumstance but rarely seen after the antagonisms and conflict of a lawsuit involving the rights of property, and too often a man's personal status.

John Dalton's statement of the case in the affair betwixt his brother and self is set forth in the following articles; his arguments in support of these will be given *in extenso* in the Appendix, so as not to disturb the general narrative:—

"Article 1st. That my father, in apportioning the paternal inheritance to us, has made a vastly great and unusual distinction betwixt my brother and self.

"Article 2nd. That he would have placed his children upon a more equitable footing if he had apprehended it was in his power to do so with reputation to himself.

"Article 3rd. That it was in his power to dispose of the whole of his property according as he should think best; but from a great deficiency in the knowledge of the law, and from a want of advice suited to the exigencies of his situation at the time he made his will, he has not availed himself of his power.

"Article 4th. That upon these considerations I think myself entitled to something more out of the paternal inheritance than I have yet received."

A body of Protestant Dissenters in the year 1786 established a New College at Manchester. This educational institution seems to have arisen out of the Warrington Academy for Dissenters, where Dr Joseph Priestley taught, as well as Dr Aikin, father of Mrs Barbauld; Dr Enfield, author of "The Speaker;" and Gilbert Wakefield. Dr Barnes, the principal of the college, wishing for a suitable person to take the

mathematical and natural philosophy course, applied to Mr Gough of Kendal, who recommended John Dalton to the situation—vacant in 1793. The terms proposed and accepted by Dalton were that he should receive three guineas per session from each student attending his lectures, with the proviso that the total remuneration of the year should not fall below £80 for each session of ten months. "Commons and rooms in the college" were allotted him at £27, 10s. per session, which being deducted from the probable and stipulated sum of £80, would leave him fifty guineas clear money for his year's work.

Thus after twelve years' residence in Kendal, where he had laid part of the foundation of his future eminence, he moved to Manchester, carrying with him the revised proofs of his "Meteorological Essays," credentials of high promise for the future. There he continued to live for the remainder of his life. His first six years were engaged in the New College; afterwards he acted as a private teacher of youth, and may be said to have devoted every available hour to the study of science.

CHAPTER V.

> "The whispering air
> Sends inspiration from her shadowy heights
> And blind recesses of the caverned rocks."—WORDSWORTH.

NEW COLLEGE OF MANCHESTER—"METEOROLOGICAL ESSAYS AND OBSERVATIONS"—THE ATMOSPHERE—EVAPORATION—AURORA BOREALIS—JOINS THE LITERARY AND PHILOSOPHICAL SOCIETY OF MANCHESTER—CORRESPONDENCE.

IN establishing the New College of Manchester, the promoters made a worthy effort to meet the growing wants of the Nonconformists, then, and long afterwards, denied access to the reputed "great seminaries of learning"—Oxford and Cambridge. Its formation marked the footing and laudable expectations of the followers of George Fox, the Wesleys, and that small and highly intellectual band who looked to John Milton and Sir Isaac Newton as their religious antitypes; and who, in the middle of the last century, had a noble advocate in Dr Joseph Priestley—himself a worker in the Warrington Academy, the headquarters of advanced opinion in politics and religion, and the foster-parent of the Manchester Institution. As a college it pertained to the progressive in art and science, and the embodiment of instruction suited to the purposes of English life; it sought for independent habits and culture, and a sounder enlightenment than "oaths of privilege," exclusive creeds, or the clothing

of knowledge in the torn and tattered garments of an antiquated scholasticism. No more fitting place for such an institution could have been found than central Manchester, where the discoveries of Arkwright and Crompton were daily in force to convert a staple produce of the New World to the material advantage of the Old, and the general interest of commerce and civilisation; and where the leading citizens were guided by the spirit of enterprise and the ennobling march of education. Moreover, the ranks of science, and not less the religious sects that held aloof from State Churches, were growing in numbers and merit; for who could claim higher distinction in the annals of British or even Continental science than Dr Priestley, Dr Thomas Young,* and John Dalton? Yet the former as a Unitarian, and the two latter as Quakers, were as much excluded from the privileges of Oxford and Cambridge as if they had been aliens in race, and paganish in principles. The New College served an essentially good purpose claiming special attention in these pages; it helped to foster the bent and genius of John Dalton when his mind, buoyant in freshness and vigour, was looking up from elementary teaching to the higher domain of physics and chemistry for its more energetic display.

The materials from which Dalton constructed his "Meteorological Essays and Observations" were obtained at Kendal, indeed written and printed there,

* Professor Tyndall, in his lectures "on light" to the people of the United States, nobly vindicated the high claims of that truly great and sagacious philosopher, Dr Thomas Young; and deserves the thanks of all men for exposing the foul and unwarranted attack made on the modest Quaker by Lord Brougham in the *Edinburgh Review*, when criticising Young's "Original Views of Light."

but published at Manchester in September 1793. A second edition was issued in 1834. It has been justly inferred that his birthplace on the uplands, and his residence up to the age of twenty-six years amid the lakes and mountains of Cumberland, made him familiar with the ever-varying conditions of the atmosphere—the deposition of vapour on the colder summits in the form of cloud, and its breaking up and disappearance when drifted into the warmer valleys. In endeavouring to account for these phenomena, he was led to those meteorological inquiries with which his name is now historically associated. The example of Elihu Robinson at Eaglesfield may have furnished him with a taste for the pursuit, and the encouragement of Mr Gough at Kendal gave it a wholesome direction.

Seeing the advantages of Mr Gough's meteorological journal, he would observe for himself; and the proximate stimulus to his meteorological fervour arose from the appearance of a grand aurora borealis on March 24, 1787. The first entry in his record of "Observations on the Weather," &c., was on the same day: "In the evening, soon after sunset, there appeared a remarkable aurora borealis, the sky being generally clear and the moon shining; it spread over above one-half of the hemisphere, appeared very vivid, and had a quick vibratory motion; about eight the heavens were overcast, and the aurora almost disappeared. *N.B.*—Three nights before, a similar aurora appeared with rather a brisk wind, and the day following windy and stormy."

This kind of general observations on the weather sufficed for a time; then he began to record, in a

tabulated form, the indications of the thermometer, barometer, and hygroscope, all of his own construction, and which are described in the following sentences: "The barometer is graduated into sixteenths of an inch. The thermometer is mercurial, with Fahrenheit's scale, exposed to the open air, but free from the sun. The hygroscope* is about six yards of whipcord suspended from a nail, with a small weight to stretch it; its scale, length of inches, beginning from no certain point — the less the number, the shorter the string and the greater the moisture."

Dr Henry possessed two volumes of this journal, comprising the years 1787–93 in Kendal, and 1793–1803 in Manchester; and it is affirmed that he continued his records with unbroken sequence to the last day of his life.

As every fact pertaining to the aurora borealis observed by Dalton in his early attempts to unravel its character is interesting, it is well to note here that in June 1788, about a year subsequent to his commencing his meteorological journal, he writes to Mr Crosthwaite that he had "added a fresh column relative to the tides of the air. What gave rise to this was a supposition that these tides may possibly give birth to some of the more minute changes in the weather; or that they may have some influence on the aurora borealis, a phenomenon which has baffled the sagacity of the last and present age to account for in a satisfactory manner."

Afterwards, in February 1793, he tells his corre-

* This simplest of all modes of determining the volume of vapour in the atmosphere was thrown aside by Dalton when he became acquainted with Leroy's method.

spondent: "I am engaged at present in observing the *daily* variation of the needle by an excellent compass. The aurora borealis disturbs the needle pretty much, perhaps half a degree or more, during its action in the air. This was first discovered by an Italian philosopher; but I have discovered a further connection betwixt these two so apparently different phenomena of the aurora borealis and magnetism. Instead of observing in future to what point the beams of light converge, observe at what *point of the compass* the beams rise *directly upwards*, or perpendicular to the horizon."

Again, in April of the same year, he writes to Mr Crosthwaite: "It will be unnecessary to remark my very high satisfaction with thy observations on the aurora. I think no one could have done better. I should wish to know whether the observation of the altitude was repeated or only taken once. Upon reviewing my observations, I find the altitude here was 53;° thine was 48°; the difference, 5°, gives the height about 150 miles. I think the true altitude here would not be 2° over or under; probably there the altitude would be within 2° of 48° also. The height of this arc must therefore be very great, and much higher than the atmosphere has usually been supposed. I should like to have at some opportunity the notes thou hast made upon the other aurora this winter, and then I think thou may desist from so watchful and particular care of these phenomena, as we shall hardly have another opportunity so fine as that above, of determining their height."

His first notion in publishing these essays was to explain the nature of the barometer, thermometer,

and other meteorological instruments;* and then to offer a few practical rules for judging of the weather, deduced from his own experience; but as his observations led him to discover the relation of the aurora borealis to magnetism, he was prompted to extend his plan, and to address "a pretty large dissertation more peculiarly to philosophers." In the first part of his volume he described the Barometer, Thermometer, Hygrometer, and Rain-gauges; and under each of these headings offered an epitome of his own observations made at Kendal, also those equally accurate of his friend Mr P. Crosthwaite of Keswick, over a period of five years—1788 to 1793; and, as far as related to the barometer and rainfall, the results of three years' observation made in London, and reported in the *Philosophical Transactions*. In other sections, also in the first part of his work, he records the height of the clouds, the thunder-storms, hail-showers, winds, frost, snow, &c., observed at Kendal and Keswick; and gives special attention to the number and character of the auroræ boreales, seen by himself and friend in their respective localities, from May 1786 to May 1793.

In the preface he leads you to infer that he had not "a superabundant assistance from books" in providing and digesting the matter contained in his volume, and therefore seeks the credit of resting his opinions on an attentive consideration of facts. A highly laudable claim, it must be conceded, yet not without its drawbacks to the student zealous to be made partaker of the history of the subject, as well as

* Meteorological Observations and Essays. By John Dalton. 8vo. London: Baldwin & Cradock. My quotations are from the second edition, published in 1834.

the special services rendered by the last competitor in the field of discovery.

Dalton's innate originality of method made him less prone to review the labours of those who had gone before him than was consistent with the position of a man who, *inter alia*, was not reticent as to his claims for novelty of research; and this occasionally placed him in a slightly equivocal attitude *qua* his contemporaries and his predecessors. Thus in 1793, after printing off his essay, he found that his theory of the trade-winds had been explained by George Hadley, F.R.S., in the *Philosophical Transactions* for 1735. Again, his more complete essay on the aurora borealis, one which he had no doubt would "attract the attention of philosophers," had been greatly anticipated by the learned Dr Halley, who formed a hypothesis to account for this curious atmospheric phenomenon by magnetism. It is of paramount import to those who seek to enlighten the world, to trace the historical development of their science, not less as a beneficial prelude and exercise to their own efforts, than as affording a groundwork to the clear understanding of the subject, and the exposition of their claims to discovery. Dalton's indifference to the labours of others was at times more apparent than real, and owed much, particularly in the investigations he made at Kendal, to his not having had access to a library of any great value; at the same time, it must be admitted that it more frequently sprang from his own solid force of mind, and the high privilege he possessed of being able to mark, learn, and with equal facility interpret the phenomena of nature for himself. When he came to the knowledge

of having been forestalled in his researches, as in the instance of De Luc's observations on the variations of the barometer, he, with due acknowledgment of the fact, had the satisfaction of stating that it was "a favourable circumstance to any theory when it is deduced from a consideration of facts by two persons independently of each other."

He gives a list of the auroræ boreales observed at Kendal and Keswick, eighteen miles distant, for seven years (May 1786 to May 1793), and seems to have been specially struck with the appearance of the aurora seen at Kendal on October 13, 1792, where a large luminous horizontal arch to the southward, with one or more faint concentric arches northward, was noticed; and all the arches exactly bisected by the plane of the magnetic meridian. His description of this *southern* light ending in the whole atmosphere being covered with streamers, rises in eloquence with the grandeur of the panorama presented to his notice: "The intensity of the light, the prodigious number and volatility of the beams, the grand admixture of all the prismatic colours * in their utmost splendour variegating the glowing canopy with the most luxuriant and enchanting scenery, affording an awful, but at the same time the most pleasing and sublime spectacle in nature. Everybody gazed with astonishment; but the uncommon grandeur of the scene only lasted about one minute; the variety of colours disappeared, and the beams lost their lateral motion, and were converted, as usual, into the flashing radiations; but

* This glowing description from Dalton's pen is difficult to reconcile with his well-known visual defect regarding the colour of objects—to be discussed in the chapter on "Colour Blindness."

even then it surpassed all other appearances of the aurora, in that the *whole* hemisphere was covered with it" (Essay, p. 64).

He discusses the "constitution, figure, height, &c., of the atmosphere; and on the subject of winds remarks (p. 83), "The inequality of heat in the different climates and places, and the earth's rotation on its axis, appear to me the grand and chief causes of all winds, both regular and irregular; in comparison with which all the rest are trifling and insignificant."

His essay, "On the Variation of the Barometer," is carefully drawn up, as the following quotation shows:

It appears from the observations (recorded in page 15 of the Essays) that the mean state of the barometer is rather lower than higher in winter than in summer, though a stratum of air on the earth's surface always weighs more in the former season than in the latter; from which facts we must unavoidably infer that the height of the atmosphere, or at least of the gross parts of it, is less in winter than in summer, conformable to the table, p. 80. There are more reasons than one to conclude that the annual variation in the height of the atmosphere, over the temperate and frigid zones, is gradual, and depends in a great measure on the mean temperature at the earth's surface below, for clouds are never observed to be above four or five miles high, on which account the clear air above can receive little or no heat but from the subjacent regions of the atmosphere, which we know are influenced by the mean temperature of the earth's surface; also, in this respect, the change of temperature in the upper parts of the atmosphere must in some degree be conformable to that of the earth below, which we find by experience increases and decreases gradually each year, at any moderate depth, according to the temperature of the seasons.

Now, with respect to the fluctuations of the barometer, which are sometimes very great in twenty-four hours, and often from one extreme to the other in a week or ten days, it must be concluded, either that the height of the atmosphere over any

country varies according to the barometer, or otherwise that the height is little affected therewith, and that the whole or greatest part of the variation is occasioned by a change in the density of the lower regions of the air. It is very improbable that the height of the atmosphere should be subject to such fluctuations, or that it should be regulated in any other manner than by the weekly or monthly mean temperature of the lower regions; because the mean weight of the air is so nearly the same in all the seasons of the year; which could not be if the atmosphere was as high and dense above the summits of the mountains in winter as it is in summer. However, the decision of this question need not rest on probability; there are facts which sufficiently prove that the fluctuation of density in the lower regions has the chief effect on the barometer, and that the higher regions are not subject to proportionable mutations in density. In the "Memoirs of the Royal Academy," at Paris, for 1709, there is a comparison of observations upon the barometer at different places, and, amongst others, at Zurich, in Switzerland, in lat. 47° N., and at Marseilles, in France, lat. 43° 15′ N.; the former place is more than 400 yards above the level of the sea. It was found that the annual range of the barometer was the same at each place; viz., about ten lines; whilst at Genoa, in latitude 44° 25′ N., the range was 12 lines, or 1 inch; and at Paris, latitude 48° 50′ N., it was about 1 inch 4 lines. In the same Memoir it is related that *F. Lavel* made observations, for ten days together, upon the top of St Pilon, a mountain near Marseilles, which was 960 yards high, and found that when the barometer varied 2¾ lines at Marseilles, it varied but 1¾ upon St Pilon. Now, had it been a law that the whole atmosphere rises and falls with the barometer, the fluctuations in any elevated barometer would be to those of another barometer below it, nearly as the absolute heights of the mercurial columns in each, which in these instances were far from being so. Hence, then, it may be inferred that the fluctuations of the barometer are occasioned chiefly by a variation in the density of the lower regions of the air, and not by an alternate elevation and depression of the whole superincumbent atmosphere. How we conceive this fluctuation in the density of the air to be affected, and in what manner the preceding general

facts, relative to the variations of the barometer, may be accounted for, is what we shall now attempt to explain.

This is referred to the varying amount of vapour.

If dependent on others for his remarks "on the Temperature of different Climates and Seasons," he is more at home on evaporation, rain, hail, snow, and dew. After advancing a series of experiments made in order to ascertain what pressure upon the surface of water is requisite to make it boil at a given temperature, it appeared to him "that evaporation and the condensation of vapour are not the effects of chemical affinities, but that aqueous vapour always exists as a fluid, *sui generis*, diffused among the rest of the aerial fluids" (pp. 127, 128); and on the following page, "that it may be determined *a priori* what weight of vapour a given bulk of dry air will admit of, for any temperature, provided the specific gravity of the vapour be given." This was breaking fresh ground; and as his opinions became a matter of public discussion, he continued his experiments, and at p. 188 more clearly defines his views by saying, "I am confirmed in the opinion that *the vapour of water* (*and probably of most other fluids*) *exists at all times in the atmosphere, and is capable of bearing any known degree of cold without a total condensation*, *and that the vapour so existing is one and the same thing with* steam, *or vapour of the temperature of* 212° *or upwards.*" After further illustration he writes, "Hence, then, we ought to conclude, till the contrary can be proved, that *the condensation of vapour exposed to the common air, does not in any manner depend upon the pressure of the air*" (p. 189). To revert for a moment to p. 135, where he contends for the theory that the vapour of

water is mixed with the air and not combined, he explains how the precipitation takes place; the multitude of exceedingly small drops forming a cloud, mist, or fog, descending very slowly, compared to clouds with heavy drops, as the resistance of the drops is as the square of the diameter—a fact cited by Dr Smith to show how Dalton's mathematical knowledge helped his meteorology.

His eighth essay, "On the Aurora Borealis," is much elaborated. In introducing it he writes, "As this essay contains an original discovery which seems to open a new field of inquiry in philosophy, or rather, perhaps, to extend the bounds of one that has been, as yet, but just opened, it may not, perhaps, be unacceptable to many readers to state briefly the train of circumstances which led the author to the important conclusions contained in the following pages." This declaration ought to induce a careful examination of his views, some of which are undoubtedly original, and should become historical, though it must be admitted that in this department of physics Dalton has not hitherto had full justice meted out to him either at home or abroad. Some of his observations had been anticipated, notably that of the aurora in relation to magnetism, by Dr Halley; but his reasonings on the subject went much beyond his learned predecessor. His views as to the luminous beams being straight and parallel to each other, and nearly perpendicular to the horizon, and probably cylindrical, were also forestalled by Henry Cavendish (*Phil. Trans.* for 1790). This historical reference, however, in no way detracts from Dalton's character as an original observer, who had ever shown himself cap-

able of the keenest discrimination and power of generalisation to elucidate not a few of the most obscure of natural phenomena.

The grand aurora seen on the 13th October 1792, led him to the discovery of the relation betwixt the phenomenon and the earth's magnetism. He writes: "When the theodolite was adjusted without doors, and the needle at rest, it was next to impossible not to notice the exactitude with which the needle pointed to the middle of the northern concentric arches; soon after, the grand dome being formed, it was divided so evidently into two similar parts by the plane of the magnetic meridian, that the circumstances seemed extremely improbable to be fortuitous; and a line drawn to the vertex of the dome being in direction of the *dipping needle*, it followed, from what had been done before, *that the luminous beams at that time were all parallel to the dipping needle:* that the beams were guided, not by gravity, but by the earth's *magnetism*,* and the disturbance of the needle that had been heretofore observed, during the time of an aurora, seemed to put the conclusion past doubt" (pp. 147, 148).

His chapter on the theory of the aurora borealis shows a greater tendency to undue hypothesis than generally marks Dalton's views, and it is to be regretted that the opinions which he hazarded in 1793, in the inchoate stages of meteorology, when cruder materials existed and more daring theories

* The able researches of Ampere on terrestrial magnetism and the electro-dynamic forces (as quoted by Humboldt from his "*Theorie des Phénomènes Electro-dynamiques*," 1826, p. 199); and the brilliant discovery made by our own Faraday of the evolution of light by magnetic forces, gave an empirical certainty to the correctness of Dr Halley's bold conjecture in 1735, and Dalton's more assured view of the aurora borealis being a magnetic phenomenon.

were admissible, should have found place in his work issued at so late a date as 1834, long after the researches of Arago, Humboldt, Farquharson, and not a few of his own countrymen, had thrown new light on the subject, more or less invalidating his earlier prognostications. Dalton considered it "almost beyond doubt that the light of the *aurora borealis*, as well as that of *falling stars* and the *larger meteors*, is electric light solely, and that there is nothing of combustion in any of these phenomena" (p. 168). He continues: "Air and all elastic fluids are reckoned amongst the non-conductors of electricity. There seems, however, a difference amongst them in this respect, dry air is known to conduct more than moist air, or air saturated with vapour. Thunder usually takes place in summer, and at such times as the air is highly charged with vapour; when it happens in winter, the barometer is low, and, consequently, according to our theory of the variation of the barometer, there is then much vapourised air; from all which it seems probable that air highly vapourised becomes an imperfect conductor, and, of course, a discharge made along a *stratum* of it will exhibit light, which I suppose to be the general cause of thunder and lightning."

He inferred from the observations collated at Kendal and Keswick, that the appearance of the aurora borealis is a prognostication of fair weather; that the aurora is more frequently followed by fair weather in summer than in winter.

After some general rules and observations for judging of the weather, Dalton furnished an appendix containing additional notes on different parts of the work, in which the reader will find much valuable

information, consisting mainly of the results of his own observations compared with other workers in the same field. The last chapter is "On the Height of the Aurora Borealis," in which he regrets, "to the no small discredit of meteorology, that there are, at this day, some persons who hold the height of the aurora to be 1000 miles, others who hold that 1000 feet may be nearer the truth."

His earlier observations led him to infer that the height of the rainbow—like arches of the aurora above the earth's surface—was about 150 English miles. The altitude of the remarkable aurora seen on March 29, 1826, he viewed as from 100 to 110 miles above the earth ; and to the latest period of his life was not disposed to yield to the larger and more correct experience of others, especially the Arctic observers. The Rev. Mr Farquharson, from full observation of the same aurora that Dalton saw in 1826, believed that there were several nearly vertical fringes of the said aurora hanging over many lines from Edinburgh to Warrington, at a *few thousand feet* above the surface of the earth. The experience of that glorious band of men, Captain (afterwards Sir John) Franklin, Sir E. Parry, Dr Richardson, &c., derived from several hundred appearances of the aurora borealis in the Arctic regions, 1819–22, &c., seemed to determine that the height of the aurora, instead of being, as supposed by Dalton and others, beyond the region of the atmosphere, is, in fact, rarely above six or seven miles, or not higher than the region of the clouds. This seemed proved by angles taken in the same moment at two distant places, always exceedingly small at one or both stations ; the extreme rapidity

with which a beam darts from one side of the horizon to the opposite side, which could not happen if a hundred miles high, or upwards; by its frequently darting its beams *beneath* the clouds, and at very short distances from the earth's surface, and by its being acted upon by the wind.

Dalton was apt to be tenacious of his own opinions; and as the investigation of the aurora borealis had been a pet and original subject in his earlier scientific days, he fought hard for his measurements of the altitude; and did not much relish the publication of Mr Farquharson's paper as stamped with British authority. Thus in a letter he addressed to Dr Faraday (Sept. 3, 1840), he makes the following comment: "I observe the Council have voted the Rev. Mr Farquharson's paper as fit for publication in the second part, 1839. The height of the aurora was 1897 yards, or rather above one mile; I calculated it 100 to 160 miles (1828); Mr Cavendish, 52 to 70 miles (1790); Robert Were Fox, 1000 miles (1831). Surely this would be an interesting phenomenon to the British Association, whether its height was 1 mile or 100 miles."

Much distrust has been expressed regarding the modes of determining the height of the aurora borealis; so that Humboldt and Arago might be justified in expressing that every observer sees his own aurora, and no two men the same; the former adding that this may arise from the phenomenon of "the effusion of light being generated by a large portion of the earth at once." The Arctic voyagers had the best chance of determining this knotty point, and much confidence may well be reposed in their observations, which went far

to contravene the measurements of Dalton. Colonel Sabine, one of the noble Arctic band, had no doubt as to the aurora occasionally resting on the surface of the sea or land; and records an instance which fell under his own observation in Skye, of an aurora, of similar character to those described by Mr Farquharson, "low in the atmosphere, having during the day the appearance of a thin mist, permitting the forms of the hills, and the irregularities of the surface of the ground, to be distinctly visible through it, and at night becoming luminous with auroral streamers proceeding from it."

On October 3, 1794, John Dalton appeared as a member of the Literary and Philosophical Society of Manchester; a society, be it remembered, that has done good service to the cause of literature and science, not only in the manufacturing districts of Lancashire, but throughout the whole of Northern England; and on the 31st of the same month made his scientific *début* by reading a paper entitled "Extraordinary Facts relating to the Vision of Colours."* Nothing could be more auspicious of the rise of the young philosopher than this first appearance before a learned society, to whom he communicated an important discovery, arising oddly enough from a personal imperfection—a discovery fraught with interest in a scientific point of view, and not without material bearing on man's non-adaptation to certain callings, trades, or professions. This essay well deserves another chapter.

His residence and engagements in the "New College" or "Academy" of Manchester; his mode of life, philosophical tendencies and work; his social

* Memoirs of the Lit. and Phil. Soc. of Manchester, vol. v. part i. p. 28.

and intellectual relations, are touched upon in the following letter, addressed to Elihu Robinson of Eaglesfield. It also recalls Manchester of eighty years ago, the old watchmen of the night proclaiming the hour on their different beats, and the condition of the sky, for the benefit of the sleeping lieges:—

MANCHESTER, 2 *mo.*, 20*th*, 1794.

DEAR COUSIN,—Amidst an increasing variety of pursuits—amidst the abstruse and multifarious speculations resulting from my profession, together with frequent engagements to new friends and acquaintance, shall I find a vacant hour to inform thee where I am, and what I am doing? Yes; certainly one hour out of sixteen some day may be spared for the purpose.

I need not inform thee that Manchester *was* a large and flourishing place. Our academy is a large and elegant building, in the most elegant and retired street of the place; it consists of a front and two wings; the first floor of the front is the hall, where most of the business is done; over it is a library, with about 3000 volumes; over this are two rooms, one of which is mine; it is about eight yards by six, and above three high, has two windows and a fire-place; is handsomely papered, light, airy, and retired; whether it is that philosophers like to approach as near to the stars as they can, or that they choose to soar above the vulgar, into a purer region of the atmosphere, I know not; but my apartment is full ten yards above the surface of the earth. One of the wings is occupied by Dr Barnes' family; he is one of the tutors, and superintendent of the seminary; the other is occupied by a family who manage the boarding, and seventeen in-students with two tutors, each individual having a separate room, &c. Our out-students from the town and neighbourhood at present amount to nine, which is as great a number as has been since the institution; they are of all religious professions; one Friend's (Quaker) son from the town has entered since I came. The tutors are all Dissenters. Terms for in-students, 40 guineas per session (10 months); out-students, 12 guineas. Two tutors and the in-students all dine, &c., together in a room on purpose; we breakfast on tea at 8½, dine at 1½, drink tea at 5, and sup at 8½; we fare as well as it is possible for any one to do. At a small extra expense we can have any friend to dine with us in our respective rooms. My official department of tutor only requires my

attendance upon the students 21 hours in the week; but I find it often expedient to prepare my lectures previously.

There is in this town a large library, furnished with the best books in every art, science, and language, which is open to all, gratis; when thou art apprised of this and such like circumstances, thou considerest me in my private apartments, undisturbed, having a good fire, and a philosophical apparatus around me, thou wilt be able to form an opinion whether I spend my time in slothful inactivity of body and mind. The watchword for my retiring to rest, is "past—12 o'clock—cloudy morning."

Now that I have mentioned clouds, it leads me to observe that I continue my meteorological journal, have two rain-gauges about a mile off, at a friend's house; one gauge is in the garden, and the other upon the flat roof of his house, 10 yards higher than the former. I find that the lower gauge catches 12 parts of rain for the upper 11. From my correspondence with my brother, it appears they have had about twice the rain we have. I hope my friends there are not altogether disappointed with my essays; please to make the following correction, and intimate it occasionally to such as have them. Page 37—total rain at Kendal 1790, should be 62.363, and for 1791, 66.200.

Among my late experiments, have had some on the artificial production of cold, but have not been able to freeze quicksilver. I find that two parts of snow and one of common salt, mixed and stirred, produce a cold regularly of—7° or 7° below O. I have sunk the thermometer below O, in a common wine glass, half filled with the mixture.

There is a very considerable body of Friends (Quakers) here; near 200 attend our first-day (Sunday) meetings. I have received particular civility from most of them, and am often at a loss where to drink tea on a first-day afternoon, being pressed on so many hands. One first-day lately, I took a walk in company with another to Stockport; there are but few Friends there, but the most elegant little meeting-house that can be conceived; the walls and ceiling perfectly white; the wainscot, seats, gallery, &c., all white as possible; the gallery rail turned off at each end in a fine serpentine form; a white chandelier; the floor as smooth as a mahogany table, and covered with a light red sand; the house well lighted, and in as neat order as possible; it stands upon a hill; in short, in a fine sunny day it is too brilliant an object to be attended, by a stranger at least, with the composure required. JOHN DALTON.

CHAPTER VI.

ON DALTON'S COLOUR-BLINDNESS.

"*Oculus ad vitam nihil facit, ad vitam beatam nihil magis.*"—SENECA.

Or,

"The eye, no servitor of duty,
But minister of all life's beauty."

OHN DALTON, passing a shop-window in Kendal, saw a pair of stockings prominently marked—"Silk, and newest fashion," and having examined their texture, bought them as a fitting present for his mother, whom he knew to be acquainted only with knit yarn and home-made sorts. On his next visit to Eaglesfield, the compliment of the stockings was duly made, and elicited the following exclamation from Dame Deborah:—"Thou hast brought me a pair of grand hose, John, but what made thee fancy such a bright colour? What, I can never show myself at meeting in them!" John was disconcerted by the maternal comments, as the colour of the said stockings appeared to his eyes a bluish dark drab, and quakerish enough in all verity. "They're as red as a cherry, John!" But John could not see this, nor could brother Jonathan, who was also present; so there were two to one in the dispute, and poor Deborah left in the minority. Being firm in her opinions she called in her neighbours,

whose verdict was "varra fine stuff, but uncommon scarlety."

As John believed in his young eyes rather than his mother's spectacled ones, the ambiguous reception of the cardinal-coloured hose dropped out of view, and apparently claimed no further consideration from him till the summer of 1793.* It will at once strike the reader as strange, that a teacher of youth, and a man of ability and observation, mingling in society where the colour of objects would often be remarked, should live to the age of 26 years without being fully alive to such an imperfection as that of not distinguishing red from green. Did he wish to hide his defects, believing them to be of slight extent and consideration? or did he look upon others, and not himself, as wanting in true perception of colour? But how did he reconcile the usual description of natural objects and scenery with his own notions of colour-distinction? When people talked of the beauty of apple blossom, and cherry ripe fruits, of bonny red hawthorn, and robin redbreasts, he must have been tried to know their meaning; and in the company of friends pointing to the setting sun in all its golden effulgence, or the bright hues of the rainbow arch, the picture must have seemed much overdrawn, inasmuch as the varied tints and radiance would be little more than streaks of light on a dull background.

* Perhaps I should qualify the statement in the text as to the date (1793), as my information tends to the belief that both John and his brother, finding themselves alike in colour perception, at some earlier date tested the vision of their scholars, in several of whom they found a similar failing to themselves; indeed, so great a percentage affected, that they were disposed to console themselves with the notion that the tables might be some day turned upon the orthodox-vision people.

In a letter to Elihu Robinson, bearing date, Manchester, 2nd month, 20th, 1794, he first introduces his defect to the notice of his "dear cousin," in the following sentences:—

I am at present engaged in a very curious investigation. I discovered last summer with certainty, that colours appear different to me to what they do to others. The flowers of most of the Cranesbills appear to me in the day almost exactly *sky blue*, whilst others call them *deep pink;* but happening once to look at one in the night by candlelight, I found it of a colour as different as possible from daylight; it seemed then very near yellow, but with a tincture of red; whilst nobody else said it differed from the daylight appearance, my brother excepted, who seems to see as I do. I never till now set about an examination into the matter. I have collected specimens of ribbons, &c., of various colours, and the result, as far as I have yet gone, is nearly as follows.

The primary colours, *orange*, *yellow*, and *blue*, appear to me much the same in the night as they do in the day, and I always distinguish them and call them by their proper names, as well as several drabs, and other mixed colours; some *reds*—for instance, vermillion—appear the same or alike day and night; but others, and more especially the different shades of *pink*, confound me most completely in the day, they all appearing *light blue;* all the dyed *greens* seem to have little or no green about them; they appear inclining to *red* or to *brown* in the day, and almost *blue* in the night; the *pinks* and *light blues*, which appear almost of the same piece in the day, are as opposite as black and white in the night, or by candlelight. A piece of silk ribbon, which some call a *very deep pink*, and others *crimson*, appears to me in the day to be a *very dark drab*, and exactly like another which they call a *mud* colour; in the night, however, the former seems *red* or *crimson*, and the latter unchanged. I was the other day at a friend's house, who is a dyer; there was present himself and wife, a physician, and a young woman. His wife brought me a piece of cloth; I said I was there in a coat just of the colour a few weeks before, which I called a

reddish snuff colour; they told me they had never seen me in any such coat, for that cloth was one of the finest *grass greens* they had seen. I saw nothing like grass about it. They tell me my table-cloth is green, but I say not, and further that I never saw a green table-cloth in my life but one, and everybody else said it had lost its *green* colour. In short, my observations have afforded a fund of diversion to all, and something more to philosophers, for they have been puzzled beyond measure, as well as myself, to account for the circumstances. I mean to communicate my observations to the world, through the channel of some philosophical society. The young women tell me they will never suffer me to go on to the gallery [in the Meeting-House] with a *green* coat; and I tell them I have no objection to their going on with me in a *crimson* (that is, dark drab) gown."

The following letter on colour-blindness is addressed to Joseph Dickinson, shoemaker, Maryport, Cumberland.

MANCHESTER, 3*d mo.*, 10*th*, 1794.

RESPECTED FRIEND, JOSEPH DICKINSON,—Permit a quondam coadjutor in ærial castle building to solicit a favour of thee. Thou must understand that I have some time ago discovered that some *colours* appear very different to me to what they do to others, and I think my case (and my brothers, for we are nearly alike in this respect) is very singular, unless the case of Friend Harris, of Maryport, be similar. I lately read Huddart's account of the Harrises in the *Philosophical Transactions* for 1777, but it does not satisfy me.

From it I understand that the most remarkable of them in this respect is deceased, but that the captain is probably still living, of whom some account is given, and whose case I strongly apprehend is similar to mine, and am anxious to know some further particulars from him in this respect. My friend Mary Cockbain suggested it to me, that thou would be a likely person to procure me this information.

I could wish thee, therefore, if thou canst make it convenient, to give my respects to the captain, and desire him on my part to answer thee some, or all of the following queries—but if he be abroad, and likely to be so some weeks, then perhaps some

of his relatives may be able to answer them in part for him ; and a communication thereof to me would be highly acceptable.

Query 1. Did he ever look through a prism? What are the chief colours he sees in it?

2. Do not *pinks*, *roses*, &c., which others call *red*, appear to him to have some affinity to sky-blue?

3. Has he distinct ideas of *red*, *orange*, *yellow*, and *green;* or does he not meet with colours which he would hesitate to pronounce one of these rather than another?

4. What are the most conspicuous colours of the rainbow?

5. Does the green woollen cloth, used to cover tables, &c., appear *green*, or anyway like grass to him ; or would he not call it a *brownish red?* Whether is common red *sealing wax* or it more nearly the colour of grass?

6. I wish particularly to know whether a ribband of a *deep pink* colour appears *remarkably* different by *day* light and *candle* light, as well as *dark green* and *crimson?*

7. Does he perceive in the day-time much difference between *crimson* and *dark drab?*

I and M. Cockbain's respects to thee, and mine to cousins Jona and Sarah Ostle, if convenient.—I am, thy assured friend,

JOHN DALTON.

Direct to me at the New College.

The following letter is clearly a reply from John Dickinson, but either its date, or that of John Dalton's communication, must be an error: probably Dalton's letter should be 3d, 10th month, 1793.

MARYPORT, *8th, 2d Month*, 1794.

RESPECTED FRIEND, JOHN DALTON,—If my quondam friend be disposed to build ærial edifices, I should be glad to be employed as a workman or at least a coadjutor in rearing those visionary fabrics, but beg to be informed where they are to be erected, that I may bring such materials as I can collect towards the construction of those pendant piles. So much in freedom, but to the point in request. Two of the Harrises, Thos. and the captain thou mentioned, are dead long ago; there is yet living other two nearly similar to those, with one I have had an opportunity, and proposed thy Queries as follows, viz.—

Quære 1st.—Did he ever look through a prism? What are the chief colours he sees in it?

Ans. 1st.—*Yellow* the most conspicuous colour he sees in it.

Quære 2d.—Do not *pinks*, *roses*, &c. which others call red, appear to have some affinity to sky-blue?

Ans. 2d.—Roses, pinks, &c., he calls *sky-blue.*

Quære 3d.—Has he distinct ideas of red, orange, yellow, and green; or does he not meet with colours which he would hesitate to pronounce one of these rather than another?

Ans. 3d.—Quite an imperfect idea of *red, orange*, and *green;* some idea of *yellow*—hesitates to call red, orange and green.

Quære 4th.—What are the most conspicuous colours of the rainbow?

Ans. 4th.—Answered in first, *yellow.*

Quære 5th.—Does green cloth used to cover tables, &c., appear green, or anyway like grass; or would he not call it a brownish red? Whether is sealing wax or it more nearly the colour of grass?

Ans. 5th.—A table-cloth *don't* appear like *grass;* red sealing-wax appears rather *darker* than *it* (only a shade), but *neither* like *grass;* no difference between *dark green* and *blood.*

Quære 6th.—I wish particularly to know whether a ribband of a deep *pink colour* appears remarkably different by daylight or candlelight, as well as dark green and crimson?

Ans. 6th.—A ribband of a deep *pink* colour appears *remarkably different* by candlelight from daylight; he calls it the colour of an *orange.*

Quære 7th.—Does he perceive in the day-time much difference between crimson and dark drab?

Ans. 7th.—He can perceive *a difference* between *crimson* and *dark drab;* he calls crimson *blue.* I was beholden to one of his brothers who has no defect, who assisted me in making the foregoing experiments.

It must be observed, he says he has no *just ideas* of any colour except *black, white,* and *yellow, some* little idea of drab. In order to try him, we prepared a basket of creweling or quilting worsted, of, I think, almost all colours and shades, and wished him to choose out a colour nearest resembling *blood,* and to our astonishment he chose out a *dark green.* We

asked him, if a white cloth or stocking should be spotted with blood if he could perceive it? he said he would not know it from dirt. We asked him, if ever he saw blood near slaughter-houses or a smithy door? he says he has perceived a wetness, and judged it to be blood from the little bells or froth frequently upon it, which is all he knew it by.

We tried him with a glass prism held in the sunshine, which, reflecting upon the wall what philosophers call a spectrum, I could not perceive it struck him more than if reflected from a looking-glass, only a little deeper, which he called yellow. I think these are all the observations I made respecting his particular case; what was a hindrance, he seemed rather backward in giving us explicit answers, arising from a knowledge of his imperfection in not having the same optics as other men.

He has another brother and a nephew, nearly similar, it is thought.

Please make my respects to J. and M. Cockbain, and accept of same thyself. I remain, thy assured friend,

J. DICKINSON.

P.S. My own affairs prevented me from writing thee sooner.

TO JOHN DALTON,
At the New College, Manchester.

MANCHESTER, 13*th of* 4*th Month*, 1794.

RESPECTED FRIEND, JOSEPH DICKINSON,—I received and perused thy letter with great pleasure, and consider my best acknowledgments to be due to thee, and to the others concerned in the business.

I find by it that friend Harris's eye is constituted like my own and that of my brother; and am induced to think from what I have heard from different quarters, that there are several individuals and branches of families up and down, who do not see colours as the generality of people do, but as we do. It is a subject that has not been much handled by philosophers; I mean, therefore, to make inquiries in different places, to ascertain the facts as well as I can, and then endeavour to account for them. The result of my labours will be communicated to the public, in some way or other. The only circumstance that was unpleasant to me was, that the friend should be

rather backward in giving you his judgment. I do not, however, wonder at it, for the reason assigned : but tell him from me, that formerly when I used to call pink *sky-blue*, and incur the ridicule of others, I used to join in the laugh myself, and then nobody thought I was in earnest ; nor did I think at that time, that there was such a great difference in the appearance of colours to me and to others, as it now seems there is. I thought we differed chiefly in *words* and not *ideas;* but now that I am certain of a real and very great difference, I make no scruple of publishing the circumstance respecting myself, in every company where I happen to be, and boldly assert with a grave face, that pinks and roses are *light blue* by day, and a *reddish yellow* by night, that crimson is a *bluish* dark drab, that all the *dark greens* (so miscalled) are of a *red* or *blood* colour, and the most disagreeable colour imaginable for a table, infinitely different from the pleasant verdure of the fields.

Having made this long introduction, I must beg leave to trouble thee a little farther on the business : I hope I shall rest satisfied with one more communication. Though I am persuaded friend Harris and I agree in ideas in general, yet I wish to ascertain the matter by particular observations. My method is this : I get a number of coloured ribbons and look at them by *daylight;* I put down the name to each, such as I think it merits, and make comparisons betwixt them, guessing as near as I can how one colour might be made from two others, by mixing such and such proportions of the colours. I then do the same by *candlelight.* I have sent herewith a specimen of colours and my opinions upon them, by which you will understand my meaning more fully. I wish him to give you his opinion of the colours, in like manner, both by *daylight* and *candlelight;* he should not see my remarks, so as to be guided by them in making his remarks to you.

[Unfortunately the colours to which this above paragraph refers, are not forthcoming ; so that both his letter and J. Dickinson's reply lose part of their value ; this is of less moment, as the history of Dalton's case, and all that really pertains to the subject, will be found in subsequent pages of this chapter.]

Now, if thou hast read these remarks with the colours before

thee, and hast kept a grave face all the while, thou hast done more than anybody here has yet; but the person thou art to show the colours to, will find nothing strange in all this, I expect. These observations will sufficiently point out to thee what sort of questions to put, in order to find whether we are alike. Thou wilt please to inform me of the Nos. in which we agree by day or night, and likewise of those (if such there be) in which we seem to disagree. I hope he will be explicit and unreserved; whatever ridicule is incurred, shall be equally divided amongst the whole fraternity of us; when we become acquainted with each other, I will heartily take my share. But perhaps we shall be so strong a party, as to be able to turn tails upon our antagonists, and convince them that 'tis *they* not *we*, who do not see things in a proper light.

Besides his remarks on the enclosed colours, I wish to know the following particulars:—

Does he not, in looking properly through a prism at the flame of a candle or fire, see a very grand *blue* or *purple*, as well as *yellow?*

Is he, or was any of the family who were in the same predicament, in any degree *shortsighted?* is his sight *strong* or *weak*, that is, can he look at a brilliant object without uneasiness? and do objects appear clear and distinct to him, the colours excepted?

If convenient, should wish to know more precisely whether the brother and nephew living, and those dead, were in the same state?

I should suppose they would have no objection to their names being mentioned in an account of the subject; if so, please to give me them.

N.B. I have kept a duplicate of this letter and the colours, so that they need not be returned.—I am, thy sincere friend,

JOHN DALTON.

[*No date.*]

RESPECTED FRIEND, JOHN DALTON.—In order to gratify thy request more fully, I have waited a long time with impatience on my part (and I daresay with more on thine) for the arrival of Captain A. Harris, whose company I thought

necessary, in order to obtain a more full investigation of the matter in request; at last his company being had, we have had an opportunity with his brother John Harris, who, I think, gave us as explicit answers as he well could, both by day and candle light, which is here annexed,* whereby I hope thou 'll be enabled to make a fair comparison between the visionary organs of the said J. Harris and thyself; I should be glad to hear reasons assigned for such a strange phenomenon.

In looking through a prism at the flame of a candle or fire he sees a *blue* as well as a *yellow*, but does not seem struck with any *grand* appearance thereof. Neither he nor any of the family are in any degree *shortsighted* (except a daughter of his, who has no defect respecting colours, is of a very *strong sight*, and can look at *brilliant objects* without much *uneasiness*). Objects appear *clear* and *distinct* to them at a great distance, colours excepted.

The brother Joseph living, we had an opportunity with by day, who, I think, is nearly similar, except not quite so defective in reds, which thou 'll perceive by his remarks on the colours, which is herewith transmitted.*

The other two brothers who are dead were in the same state, whose names were Thomas and Jonathan.

Indeed, friend John, thou conjectured right; I did not read thy remarks with a grave face, but on the contrary with many fits of risibility which I am subject to, but I think more so on hearing J. Harris' remarks and my own reflections thereon. I find by your accounts you must have very imperfect ideas of the charms, which in a great measure constitute beauty in the female sex, I mean that rosy blush of the cheeks, which you so much admire for being *light blue*, I think a complexion nearly as exceptional in the fair sex as the sunburnt Moor's or the sable Ethiopian's, consequently (if real), a fitter object for a show than a wife.

The following are their remarks by daylight and candlelight after thy manner; but observe these are Joseph's remarks by day only, we had no opportunity with him by candlelight. I showed him the effects of a prism, and observed he was like John, seeing no colours but *yellow* and *blue;* I believe red seems

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* See the explanation within brackets in page 106.

cloudy to them. I am glad to find they have no objection to having their names made use of in what decent manner thou may think proper, provided it may be of benefit to mankind. After relaxing my muscles a little on writing these above remarks of theirs, I have composed myself and am glad. I think I have nothing more to communicate at present on the subject. Wishing it may give thee full satisfaction, and prove of real advantage to thyself and the community at large, is the sincere wish of thy assured friend, J. DICKINSON.*

As soon as Dalton had collected his ideas on colour-blindness, derived from a study of his own and brother's vision, and the facts obtained by J. Dickinson, he read a memoir on the subject, entitled "Extraordinary Facts relative to the Vision of Colours," to the "Manchester Literary and Philosophical Society," at their meeting on October 31, 1794. The main facts of his memoir are to be found in the following excerpts :—

"In the course of my application to the sciences, that of optics necessarily claimed attention; and I became pretty well acquainted with the theory of light and colours before I was apprised of any peculiarity in my vision. I had not, however, attended much to the practical discrimination of colours, owing,

* This Joseph Dickinson of Maryport was a shoemaker, and father of Isaac Dickinson, now of Whitehaven. The said Joseph was sent to learn the art of St Crispin in Roper Street, Whitehaven, in 1778, and had hardly got reconciled to his sleeping garret, when a great tumult was heard in the street; and on looking out he saw the shipping on fire. He rushed down to the strand, and on to the rocks, where the bold pirate, Paul Jones, was seen hauling aft his starboard sheets and making off after his victory, laughing over his taffrail at the efforts of the tradesfolk to rake the gravel out of their great guns in the halfmoon battery.

Isaac Dickinson, now living at Whitehaven, has colour blindness like the brothers of his grandfather; his vision resembles very closely that of John Dalton. Isaac objects to be considered "colour-blind," and wishes to know on whose side—the minority like himself, or the majority

in some degree, to what I conceived to be a perplexity in their nomenclature. Since the year 1790, the occasional study of botany obliged me to attend more to colours than before. With respect to colours that were *white*, *yellow*, or *green*, I readily assented to the appropriate term. *Blue*, *purple*, *pink*, and *crimson* appeared rather less distinguishable, being, according to my idea, all referable to *blue*. I have often seriously asked a person whether a flower was blue or pink, but was generally considered to be in jest. Notwithstanding this, I was never convinced of a peculiarity in my vision, till I accidentally observed the colour of the flower of the *geranium zonale* by candlelight, in the autumn of 1792. The flower was pink, but it appeared to me almost an exact sky-blue by day; in candlelight, however, it was astonishingly changed, not having then any blue in it, but being what I called red, a colour which forms a striking contrast to blue.

"It may be proper to observe that I am shortsighted. Concave glasses of about five inches focus suit me best. I can see distinctly at a proper distance; and am seldom hurt by too much or too little light; nor yet with long application.

"My observations began with the solar *spectrum*, or coloured image of the sun, exhibited in a dark room by means of a glass prism. I found that persons in

who console themselves with being perfectly endowed—the colour-blindness exists? He professes to see colours bright and brilliant as other persons; and asks, Can anything be grander than a cherry tree with leaves the same colour as the cherries? Addressing himself to me he remarked: "You say cherries are red, well, what colour is red? or can there be a more beautiful flower than a sky-blue rose? People say the rose is pink, but who can clearly describe the colour of pink, it may be, when viewed with a lamp, yellow or green?"

general distinguish six kinds of colour in the solar image; namely, *red*, *orange*, *yellow*, *green*, *blue*, and *purple*. To me it is quite otherwise—I see only *two*, or at most *three* distinctions. These I should call *yellow* and *blue;* or, *yellow*, *blue*, and *purple*. My yellow comprehends the *red*, *orange*, *yellow*, and *green* of others; and my *blue* and *purple* coincide with theirs."

He thus sums up the characteristics of his own and his brother's vision:—

1. In the solar spectrum three colours appear, yellow, blue, and purple. The two former make a contrast; the two latter seem to differ more in degree than in kind.

2. *Pink* appears by daylight to be sky-blue a little faded; by candlelight it assumes an orange or yellowish appearance, which forms a strong contrast to blue.

3. *Crimson* appears a muddy blue by day; and crimson woollen yarn is much the same as dark blue.

4. *Red* and *scarlet* have a more vivid and flaming appearance by candlelight than by daylight.

5. There is not much difference in colour between a stick of red sealing-wax and grass by day.

6. Dark green woollen cloth seems a muddy red, much darker than grass, and of a very different colour.

7. The colour of a florid complexion is dusky blue.

8. Coats, gowns, &c., appear to us frequently to be badly matched with linings, when others say they are not. On the other hand, we should match crimsons with claret or mud; pinks with light blues; browns with reds; and drabs with greens.

9. In all points where we differ from other persons, the difference is much less by candlelight than by daylight.

In concluding his paper, he thought it probable that the sun's light and candlelight, or that which we commonly obtain from combustion, are originally constituted alike; and that the earth's atmosphere is properly a *blue fluid*, and modifies the sun's light so as to occasion the commonly perceived difference.

In reference to *red* by daylight, he says, "I have seen specimens of *crimson*, *claret*, and *mud*, which were very nearly alike. . . . The colour of a florid complexion appears to me that of a dull, opake, blackish blue, upon a white ground. A solution of sulphate of iron in the tincture of galls (that is, dilute black ink) upon white paper, gives a colour much resembling that of a florid complexion. It has no resemblance of the colour of blood. Blood to me is not unlike that colour called *bottle-green*. Stockings spotted with blood or with dirt would scarcely be distinguishable. . . . By day some reds are the least showy imaginable; I should call them dark drabs." It thus appears, as Dr G. Wilson remarks, that as Dalton saw the red end of the spectrum dark or darkish, so certain red objects showed to his eye as dark blue, dark brown, dark drab, mud-coloured, dirt-coloured, or even like ink; so he seems to have been in certain circumstances blind to red.

Sir John Herschel and Sir David Brewster, who both paid much attention to Dalton's case, have expressed their conviction that he saw as long a spectrum as others did, but that the red extremity appeared to him yellow. Herschel, in addressing

Dalton, says :—"It is clear to me that you, and all others so affected, perceive *as light* every ray which others do. The retina *is excited* by every ray which reaches it." And again,—"It seems to me that we (the normal-eyed) have three primary sensations where you have only two. We refer, or can refer in imagination, all colours to three—yellow, red, and blue. All other colours, we think, we perceive to be mixtures of these, and can produce them by actual mixture of powders of these hues, whereas we cannot produce these by any mixtures of others. . . . Now, to eyes of your kind, it seems to me that all your tints are referable to two." A similar conviction is stated by Herschel, in his treatise on light ("Encyclo. Metropol."), in reference to the colour-blind as a class :—"All the prismatic rays have the power of exciting and affecting them with the sensation of *light*, and producing distinct vision, so that the defect arises from no insensibility of the retina to rays of any particular *refrangibility*."

Sir David Brewster ("Letters on Natural Magic," 1832, p. 31) thus writes :—"In all those cases [of colour-blindness] which have been carefully studied, at least in three of them, in which I have had the advantage of making personal observations ; namely, those of Mr Troughton, Mr Dalton, and Mr Liston, the eye is capable of seeing the whole of the prismatic spectrum, the red space appearing to be yellow. . . . I have lately shown that the prismatic spectrum consists of three equal and coincident spectra of *red, yellow,* and *blue* light ; and consequently, that much yellow and a small portion of blue light exist in the red space ; and hence it follows that those eyes which see only

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two colours—viz., *yellow* and *blue*, in the spectrum, are really insensible to the red light of the spectrum, and see only the yellow with the small portion of blue with which the red is mixed. The faintness of the yellow light which is thus seen in the red space confirms the opinion that the retina has not appreciated the influence of the simple red ray."

Though such eminent men as Dugald Stewart and M. Sismondi laboured under the infirmity of abnormal colour-vision, the fact of John Dalton reporting his own case, led the Continental *savans*, and notably those of the Academy of Geneva, to designate the defect of colour-blindness "Daltonism" and its subjects "Daltonians." This was hardly fair to our countryman, to have his physical weakness trumpeted to the world when he had won immortality in the fields of science; his name, if used at all for special distinction, should have been applied to his discovery of the Atomic Theory.

Various terms, chiefly of Greek origin, have been applied by Whewell, Herschel, and others, to designate the defect experienced by Dalton. Perhaps the name *Chromato-Pseudopsis*, or a false vision of colours, would be generally applicable, but not entirely so, as there are gradations beginning with deficient colour-sight, and ending in monochromic or achromic vision, or true colour-blindness. The term "colour-blindness" introduced by Sir D. Brewster is, after the explanation just given, most expressive and simple, and as it is generally adopted by scientific men, will be used in this brief sketch.

Professor Wartmann* of Geneva has recorded a

* Those who seek for a complete history of the subject under dis-

case of doubtful colour-vision as occurring in 1684, but the first really well-authenticated instances of colour-blindness were met with in a family of the name of Harris,* residing at Maryport, Cumberland, to which reference has been so pointedly made by John Dalton's inquiries in the foregoing letters to J. Dickinson.

A few words will show how colour-blind persons differ from their more fortunate neighbours. Without aiming at a scientific analysis of light, I may be permitted for the purpose of this memoir to assume that there are three simple elementary or primary colours, red, blue, and yellow, visible by daylight to perfect eyes; besides white, the mutual neutralisation of these colours; and black, the absence of these colours. Perfect natural vision is a three-colour vision, and each of the colours may be changed by addition of white into *tints*, and by addition of black into *shades*. Then the primary colours may be mixed with each other so as to produce by the addition of red to yellow, scarlets and orange colours; or by the addition of red to blue, crimsons and purples. All these secondary colours are visible both in their entirety, and throughout a long series of tints and shades to a perfect eye; as also the mixtures of these secondary colours with each other, giving rise to russet browns, olives, &c.

cussion will do well to consult Professor Wartmann's works translated in Taylor's "Scientific Memoirs," for 1846, and the able monograph of Dr George Wilson, of Edinburgh, "Researches in Colour-Blindness," Edinburgh, Sutherland & Knox, 1855.

* Capt. Joseph Huddart, whose biography forms part of the fourth series of "Cumberland Worthies," addressed a letter to Dr Joseph Priestley, the chemist, characterising the peculiar condition of some of the Harris family, which was published in the *Philosophical Transactions* for 1777.

The colour-blind distinguish white and black perfectly enough, some few having no other perception of colours than light and shade. The great majority of them, however, distinguish two only of the primary colours, *yellow* and *blue;* but are quite at fault with *red*, which they confound with *green*, with *brown*, with *grey*, with *drab*, and occasionally other colours; and not unfrequently red is altogether invisible, or appears black. So the colour-blind possess a *bicolor*, or two-colour vision of *yellow* and *blue*, and these only when deep or full; but as they are liable to mistake purple for blue, they in reality are clearly cognizant only of yellow.

The most serious defect in the colour-blind is in reference to red and its complementary colour green. Now, by artificial light, such as lamps, candles, gas, red is less liable to confusion with green than by daylight; in other words, artificial light lessens colour-blindness—a circumstance that is often adverted to by those so affected, for the purpose of showing that their vision is not so bad as it has been represented.

The observations of Professor H. W. Dove (*Philosophical Magazine*, Oct. 1852) tend to show that "we all become sooner blind to red than to other colours, so that between us and the colour-blind persons emphatically so-called, there is but a difference in degree."

It will be understood that though there is a defective or negative vision of colours in the colour-blind, their vision in other respects is good; nay, not unfrequently they have a very nice perception of form and outline, not only in full but in faint light; as was well evidenced in Dalton's case.

Colour-blindness has been met with in all ranks and stations of life, including the peasant and painter, the professor and the philosopher. The affection is congenital, hereditary, and apparently incurable. It has been traced through five generations, and whilst descending by both the father and the mother's side, it always attaches to the sons rather than the daughters; as many as six brothers have been found with this defect of vision. The great preponderance of males so affected compared with females, as far as has been hitherto ascertained, seems curious, if not unintelligible, excepting on the supposition of a general reluctance on the part of women to admit of either a moral or physical weakness touching their personal attributes, or calculated in any way to affect their matrimonial prospects.

Dr George Wilson believed that "the number of males in this country who are subject to this affection of vision is not less than one in twenty, and that the number markedly colour-blind, *id est*, given to mistake red for green, brown for green, purple for blue, and occasionally red for black (as in Dalton's case), is not less than one in fifty. The actual number of the markedly colour-blind detected in an examination of 1154 males in Edinburgh, was one in fifty-five, and the parties examined were students, soldiers, and policemen, born in various parts of the British dominions."

My late esteemed friend, Dr William Mackenzie of Glasgow, one of the best oculists of his day, only saw two cases of colour-blindness in thirty years in 40,000 opthalmic patients. This would tend to show that there is no relation between diseased con-

ditions of the eye and the curious phenomena now under discussion. Insensibility to colours is in nowise incompatible with distinct vision in other respects; nay, probably, as the retina in persons like Dalton is unfatigued by the impression of colour, the sensitiveness to light is longer retained; in other words, ordinary vision is rather strengthened than otherwise, obviously seen in Dalton, who suffered nothing from long application of his eyes.

Many odd mistakes have been committed by the colour-blind; but how some of them came to be painters, and dyers, and tailors, is difficult to comprehend. A house painter who could only distinguish black and white, and required his wife's eyes to keep him right, attempted in her absence a stone tint for an outside wall, and had covered some yards of the building with a fine *blue* before he was corrected. A tailor, to whom black appeared green, or in particular instances crimson, repaired the parson's black silk, and the officer's dark blue coat, with crimson, to the great chagrin of his employers. An officer daily mingling with people in bright colours, purchased a blue uniform coat and waistcoat, with *red* breeches to match!

When Dalton had made up his mind to visit Paris in 1821, a good external appearance seemed to him very requisite; accordingly he went to a tailor's shop in Market Street, Manchester, and said: "I am going to Paris, I want thee to sell me some good strong drab cloth." Passing his hand over a piece lying on the table, he remarked, "I think this will suit, just the colour I want, and stout good cloth." "Why," said the tailor, "Dr Dalton, that is a piece of scarlet cloth

for hunting coats!" "Ah," replied the Doctor, "I see thou knowest the infirmity of my eyes."

The seat or cause of colour-blindness is a mystery. Two theories have been advanced on the subject. The one refers the false perception of colours to the *chromatic condition* of certain portions of the optical apparatus of the eye; the other to the *peculiar organisation of its nervous apparatus,* including so much of the brain as is essential to vision.

The chromatic theory was upheld by Dalton, who was strongly of opinion that one of the humours (the vitreous) of his eye was a *coloured* medium, probably some modification of blue. But the examination of his eyes after death revealed nothing in support of his views. Mr Ransome, who made the *post mortem,* states that "the aqueous humour of one of them was found to be perfectly pellucid and free from colour. *The vitreous humour and its envelope* (the hyaloid membrane) *were also perfectly colourless.* The crystalline lens was slightly amber-coloured, as usual in persons of advanced age. The tunics, retina, choroid, and sclerotic, with their subdivisions, presented no peculiarity." Dr George Wilson discusses the chromatic theory at great length, chiefly on the relation which the retina, the yellow spot of the retina (the *foramen* of Sœmmering*), and choroid membrane bear to colour-vision.

The second, or *Cerebro-retinal* theory of colour-blindness, has found supporters in some of the best authorities of the day. In reference to the *cerebrum*

* Any opinion based on the "yellow spot of Sœmmering" should be received with caution. See my "Life of Robert Knox, the Anatomist," pp. 27 and 31, for some curious observations thereon.

or brain part of this theory, the phrenologists attribute the power of distinguishing colours to a particular part of the brain lying over the roof of the orbit, and, when largely developed, rendering one part of the superciliary ridge specially prominent. Dalton's forehead, and strongly-marked eyebrows, lent no sanction to this opinion; for as already stated, this portion of his cranium bore considerable analogy to that of Sir Isaac Newton, whose knowledge of colours was exceedingly good.

The only remaining explanation of colour-blindness is to be found in the retina itself, that portion of the eye upon which vision truly and essentially depends. Now, all the great authorities on optics, Young, Brewster, Herschel, Müller, construct their theories of colour-blindness entirely on the retina, believing some parts of its structure to be deficient, or that its sensibility to colour is impaired in those whom we call colour-blind.

In the discrimination of colour, remarkable inequalities would appear to exist in different parts of the retina, all of us being more or less blind to red in the outermost parts of our field of vision. The accomplished Helmholtz* states that "all red colours appear much darker when viewed indirectly. This red-blind part of the retina is most extensive on the inner or nasal side of the field of vision; and according to recent researches of Woinow, there is at the furthest limit of the visible field a narrow zone, in which all distinction of colour ceases, and there only remain differences of brightness. In this outermost circle everything appears white, grey, or black."

* "Popular Scientific Lectures," p. 248.

The Berlin professor had the good fortune to examine the Transactions of the Royal Society of London, and there met with what he calls a wonderfully simple solution of the theory of colours, laid down at the beginning of the century by the renowned philosopher Thomas Young. According to Dr Young "there are in the eye three kinds of nerve-fibres, the first of which, when irritated in any way, produces the sensation of red, the second the sensation of green, and the third that of violet. He further assumes that the first are excited most strongly by the waves of ether of greatest length; the second, which are sensitive to green light, by the waves of middle length; while those which convey impressions of violet are acted upon only by the shortest vibrations of ether."

The discussion of this subject would be apt to lead far beyond the lines of this memoir. It may suffice to state that those who suffer from red-blindness are deficient in that class of nerve-fibres which are sensitive to red rays, or that these fibres are so sparingly distributed as to be incapable of excitation.

The observations of Max Schultze on the rods of the retina of birds and reptiles, in which he found a number of rods containing a red drop of oil in their anterior extremity, or looking towards the light, while other rods contained a yellow drop, and others none at all, are of great interest. And as Helmholtz has said, "we may with great probability regard these rods as the terminal organs of those nervous fibres which respectfully convey impressions of red, of yellow, and of blue light."

Hitherto there has been but one *post mortem* examination of the colour-blind, namely, Dalton himself, so

that the theories afloat have not been subjected to the proper test; and a pathological inquiry is essential to the elucidation of the cause of this anomalous condition.

It is worthy of note that Quakers show a greater proneness to colour-blindness than any other class or denomination; that is, if our present statistics can be relied upon. The Harrises of Maryport were of this persuasion, and where the largest number have occurred in one family, it has been generally among "Friends." The regular avoidance by this worthy sect of anything like gay colours in dress or household adornment, might so far deaden the acuter perception of the finer shades of colour, and possibly induce in the course of a few generations a hereditary indifference in that direction, and so subject the eye to a modified colour-blindness. My friend, Dr George Wilson, was disposed to support this theory, and to view it rather as *un fait accompli.* The period, however, elapsing between the stirring days of George Fox, and the first appearance of colour-blindness in the Maryport family (Harris), being less than a century, implies that the first instances of this defect noticed among Quakers in England, owed little or nothing to the drab surroundings of their ancestors. It would be none the less interesting to ascertain how far colour-blindness prevails among "Friends," as compared with the general community; and if this is to be done, it should be done speedily, as the rank and file of the regiments of drab are rapidly thinning, and bid fair to die out before the end of the present century—their present number of *bona fide* members fairly told, probably not exceeding 9000 persons in England and Wales.

As colour-blindness has hitherto proved incurable, care should be taken by parents and guardians to restrict those affected by it to lines of pursuit, be it art, trade, or profession, in which colour forms no essential part. It would be absurd to send a colour-blind person to house painting, dyeing, and weaving; and equally futile to make the most educated a botanist, an analytical chemist, or physician. Above all other pursuits railway service and sea-faring should be avoided by such persons; and it is especially demanded of railway authorities to test the visual capacity of all their employed, seeing that the colour-blind often mistake bright *red* for *green*, *dark red* for *brown*, and *red* for *black*, as well as dark or light shades of all colours for each other: thus the caution signal *green* is liable to be mistaken for the danger signal *red*, and the latter, when it appears *black*, not to be seen at all. That accidents have occurred, and do still occur, from employing the more or less colour-blind, and that many valuable lives have been sacrificed in this way, can hardly admit of a reasonable doubt.

If there be any organ in the body more likely than another to show weakness of function or defect, it should be the eye, in all its wonderful organisation, and delicacy, and beauty, resting also for its manifestations on the motions of a matter of extreme tenuity—the light,

> "From matter streaming, it makes matter bright,
> Matter arrests it on its onward flight;"

a world of light and colour vibrating through the ethereal atoms of the universe.

Of what moment was it to Dalton to note the climatic conditions and physiognomy of Nature, the delicate buds of spring, the leafy woods of summer, and the yellow ripening of autumn in all their display of variety of colour, exquisite contrast, and beauty! The organic kingdoms would present to him little more than an arrangement of form, whereas to the normally-constituted and æsthetic vision they offered alternate brightness and tint, and to the devotee a hieroglyphic of the Eternal, in whose material fashionings were to be found the indications of a spiritual existence. Wanting one of the chief senses of the naturalist, or having its capacity and fitness impaired, his scope of observation would be more or less limited to the forms and nomenclature of organisms, so far worthy of pursuit, but, comparatively speaking, little more effective than peeling off the outer bark of the tree, when a more enlarged observation would treat of the circulating sap vessels, the structural pith and entire physiology. In morphology, a subject akin to his breadth of inquiry and powers of generalisation, as it was to Goethe, he might have shone; for there, as the noble exponent of the science aptly wrote—

> "All shapes are similar, yet all unlike,
> The chorus thus a hidden law reveals."

The æsthetic feeling being thus so far impaired, Dalton might well remain a bachelor; true beauty, flowing from colour and emotional surprise, could offer no charms to him. For what purpose, beyond the interchange of commonplace thoughts, did he associate with the pretty Quakeresses of Kendal, of

fair complexion, peach-blossom cheeks, ruby lips, and auburn hair, decked out in simple yet seductive forms of cap and ribbon? These bright and natural emblems of Hymen worship touched not the inner chords of John Dalton's heart. He might have exclaimed, in the words of Horace,

> "Heu! quóve color? decens
> Quò motus?"

The "Quò fugit Venus" was not applicable to one who never enjoyed the real flame of love, but only the smallest of flirtations, nay, hardly so much, with a pretty widow. Circumstanced as he was to the æsthetic and beautiful of the world, the best thing he could do for his own satisfaction was to follow the science that dwelt in numbers, algebraic forms, and chemical symbols; for there he could be on a par with other men, making use of black and white lines to illustrate their abstract formulas.

CHAPTER VII.

"*Modifications in the religious sentiments and the tenderest social feelings of men, and changes in the special habits of those who exercise an influence on the ideas of the mass, give a sudden predominance to that which might have previously escaped attention.*"—ALEXANDER VON HUMBOLDT.

HIS IDEAS ON QUAKER-WORSHIP—THE HANDSOME WIDOW AND LOVEABLE SPINSTER—POETICAL EFFORT—ESSAYS ON THE QUANTITY OF RAIN AND DEW—ON THE POWER OF FLUIDS TO CONDUCT HEAT—MAXIMUM DENSITY OF WATER—THE SECRETARYSHIP OF THE LITERARY AND PHILOSOPHICAL SOCIETY—ESSAYS ON HEAT AND COLD PRODUCED BY CONDENSATION AND RAREFACTION OF AIR—CONSTITUTION OF MIXED GASES—FORCE OF STEAM—EVAPORATION—EXPANSION OF GASES BY HEAT.

JOHN DALTON, though reticent on religious questions, and never voluntarily entering upon their discussion, felt himself bound to obey regimental orders; and in outer habiliments, no less than in denominational observances, justly ranked as a "Friend," or faithful disciple of George Fox. His first visit to London in May 1792, evidently arose out of a wish to attend the "yearly meeting of Friends,"* where this pious

* The Prince Regent, afterwards George the Fourth, fond of excitement and adventure, laid a wager with one of his Beau Brummel jovial crew that he could appear as a Quaker at the great yearly meeting in London. In suitable drab and broad brim he entered the meeting-house, and took a seat, a little disconcerted, perhaps, to find that "Women Friends" sat apart from the men. Whether his *embonpoint*, jaunty air, or non-quakerish countenance betrayed him as he passed

and peaceful people most do congregate from all parts of the empire; either as representatives of their respective "monthly meetings," or as zealous partakers of the wisdom of the higher orders of the ministry assembled to discuss the laws and discipline of the body, and, it may be added, with a solemnity becoming those who seek the Divine Spirit in all matters relating to their moral and religious welfare.

Coming from the quietude of a small market town like Kendal, he naturally looked upon London as "a most surprising place, worth one's while to see once, but the most disagreeable place on earth for one of a *contemplative turn* to reside in constantly." The number and noise of the hackney coaches engaged his attention as much as any novelty he saw, and his numerical habits led him to count the number of coaches conveying Friends to their meeting-house, and he found no less than one hundred and four in the service. There is no indication of his having made the acquaintance of any of the scientific men in the metropolis on the visit, his time being apparently absorbed with his co-religionists, and a general glance at the wonders of the New Babylon.

He felt more than usual interest in the mode of worship practised by Friends, as is revealed by a

through the porch, some of the elders scrutinised him very closely, and were consequently led to express a doubt as to his claims to a seat in the synagogue. After a few minutes' consultation on the subject, an aged Friend approached the Prince, and put this simple question—"May I ask thee to say what monthly meeting thou belongs to, friend?" This interrogation was beyond the card of His Royal Highness, so he found it convenient to withdraw from the meeting; not, however, without a polite uplifting of his broad brim to the wondering Friends as he passed from the threshold of the meeting to the open street.

record in his Journal of 1795, where he states that, along with another Friend, he "drew up a petition to the yearly meeting soliciting permission to use music under certain limitations." To those who are aware of the extreme simplicity guiding Friends in their religious attitudes, where there is no tuning to the heavenly spheres, no vociferation, but much silent meditation, nay, a silence not infrequently quite profound during the hour and a half of their assembling, it is needless to say that so bold an innovation as that suggested by Dalton must have taken the "Conscript Fathers," and, it may be added, "Mothers," seeing that the majority of Quaker ministers are women, with no small amount of astonishment.

As there is nothing more akin to the higher religious feelings of man than his sympathetic relations with the tender sex, the following love episodes in John Dalton's staid and invulnerable bachelorship may find appropriate place here. In a long letter to Elihu Robinson (February 20, 1794), after describing his residence in the New College, his varied engagements, and observations on colour-blindness, he frames a supposition for his Eaglesfield friends—"I wonder whether John is going to marry yet or not?" and then describes with becoming discretion his experiences with a pretty love-making widow in the circle of "Friends." For a time he seemed to feel with Shakespeare's "Biron"—

> "From woman's eyes this doctrine I derive;
> They are the ground, the books, the academies,
> From whence doth spring the Promethean fire.
> Why, universal plodding prisons up
> The nimble spirit in the arteries."

issued in 1803 (Ostell, Ave Maria Lane, London, 12mo, pp. 122). The book was dedicated to John Horne Tooke, M.P., to whom he expressed his obligations in the following terms: "To the literary world it will be unnecessary to observe that in this department, etymology, I have drawn a great deal from *one source;* but I have not rested satisfied with the *ipse dixit* of the author of 'The Diversions of Purley,' when time and opportunity afforded me means of confirmation and inquiry." He writes to his brother: "I have sent a copy to Horne Tooke, but he has got *things* to attend to now, instead of *works.*" This was in allusion to Mr Tooke being then arraigned on a charge of high treason.

This concisely-written Grammar found favour with some literary critics, and was not without a certain degree of merit, were it only as an innovation on the grammatical systems then in use. Thus, he banished the articles from the parts of speech, and associates them with the adjectives under the title of definitives.

At p. 8, he says—

"It may be taken as an axiom that all time or duration, in the strictness of the terms, is either *past* or *future.* But for the purposes of speech we must have a present time of some duration, which must necessarily be comprised of a portion of the past and a portion of the future, having the present, *now* or *instant*, as a boundary between them. Its length may be what we please to make it.

"Grammatically speaking, therefore, there are three times, present, past, and future; though strictly and mathematically speaking, we can admit only two, past and future," &c.

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insisting upon a more careful search, a dusty corner revealed a large parcel of his Grammars. The opinion prevailed that few were sold beyond the wants of his own academical classes.

The Rev. Sydney Smith, in one of his amusing contributions to the *Edinburgh Review*, avowed his belief that if "Quakers" had prevailed in numbers, the world would have been a very stupid and dull affair. Not improbably he formed his estimate from some demure Obadiah, or ancient spinster Tabitha of the order drab, as little seen now-a-days as the ultra "broad-brim beaver" or "coal-scuttle bonnet" of a past generation. Though stiff in manners, and formal in phraseology, the "Friends" are a worthy people, who cultivate the homely virtues, and enjoy the amenities of life as happily as any class of her Majesty's subjects. Their youths are well trained in schools of their own persuasion; where order, occupation, and the culture of independent habits and resources, are strongly inculcated. All "Friends" are neat in their attire and personal and domestic relations; they are much given to hospitality and social fraternisation with members of their own order; and their homes are enjoyable. Another feature of their lives is a tendency to holiday-making and travelling to and fro visiting their brethren—a cheap and pleasant mode of being entertained whilst gathering a knowledge of the outer world.

John Dalton, like his fraternity, had a great *penchant* for rambling during the summer months; and one of these excursions may be appropriately introduced here by quotations from a long letter of his to Elihu Robinson. Though not in exact chronological order, the letter may be viewed as episodical to the general narrative, and help to lighten the dry scientific details prevailing towards the close of this chapter. Dalton's companion was a brother of the "amiable

Hannah." The young Quaker pedestrians lost their geographical bearings in a way to make them the laughing-stock of an English village.

MANCHESTER, *1st month, 27th*, 1798.

DEAR COUSIN,—It is now three months since I received thy kind notice of my letter of last summer. My engagements of teaching in public and private, together with my own literary pursuits and the necessity of frequent visits amongst an extensive acquaintance, occupy my time so regularly from 8 in the morning to 12 at night, that I rarely find an opportunity for occasional correspondence. However, I mean herein to give thee a further account of our tour, agreeable to thy request; only I am afraid that some part will only be *a tale twice told*, as I am not aware of what I wrote last.

We had a very pleasant passage across the Mersey from Liverpool towards Chester (about 12 miles), and had a fine view of Beeston Castle (about 30 miles), whither we were aiming; we reached Chester in the canal boat about 5, and having drank tea, started on foot for Tarporley (10 miles), anticipating the twofold pleasure of a fine view from the castle the next day, and of there partaking of a cold collation in the open air in company with my amiable friend Eliza Rothwell and her daughters, who were on a visit. They had, however, been suddenly and unexpectedly called home the day before; but had taken care to secure us a welcome reception at their friend's house, which was situate on a hill about three miles from the castle, and in full view of it, a valley intervening. In the morning we had no sooner drawn aside the curtains, than the rising sun shone in upon us, and discovered the most elegant lodging room I was ever in. But that was not all; the views from the windows on two sides of the room were exquisite; we seized upon a large reflecting telescope and pointed it to the castle before we were dressed. After spending the morning there we went over to the castle, which answered our expectation, and then proceeded to Whitchurch that night. Rose at 6, and would go to Wem to breakfast (11 miles); when we had gone two, came to a village where we were told to inquire for a footroad which was about three miles, and said to be at least a mile nearer; there were many

cross roads at the village, and we asked at a flax shop on our *left*, which was the short road, and were directed to turn to our left at a barn, &c., &c., and found all as was told; presuming, however, that the main road was right forward; but it happened to be a road still more to the left, as we found to our cost in the sequel. An hour after we got into the main road at right angles to our last track, and turned of course to the left; soon after came to a stone, but its inscription defaced. We rested awhile, and a person came up who told it was four miles to Wem; unfortunately, we were *standing still* when we asked. We proceeded, and another stone presented itself likewise defaced, which we called three, and going on we began to look long for two, when we entered a village where were many cross roads. My companion, impatient for his breakfast, would inquire of somebody, and stepped aside to a shop on his *right*, whilst I went up to a guide post. I had not got up to it before I heard a voice behind me:—"*We have been here before this morning.*" I went on,—it repeated, "*I say, we have been here before this morning.*" "What dost thou mean?" said I, turning round; "*Well, I say we have been here before this morning, this is the flax shop I inquired at before, and yonder is the barn.*" I perceived it was so. The very same men that had directed us before came out, and seemed as much surprised as we, inquiring whether we had been at Wem, as we had asked of them the way about two hours before. Our surprise and chagrin may be easily conceived. They told us to go back the way we had last come, and then they defied us to get wrong; which we did accordingly. In this manner we paid for a piece of advice, "Never to leave the main road without knowing well on which hand you have it." We could get nothing but *bread and water* till we got to Wem at 11, and then we had each about eight or ten cups of coffee.

He visited Shrewsbury, Coalbrookdale, Birmingham, &c.; his comments thereon need not detain the reader. After spending a fine day at Blenheim House, he continues:—

At Oxford we had a line to one of the Fellows, who showed us what was worth attention at that celebrated place, as the

libraries, gardens, buildings, &c. At Slough, we saw Dr Herschel's great telescope; and the royal family at Windsor; also the college at Eton. The places we visited, and the observations made in the metropolis, I must omit, as they would require some room. In going down to Bristol we stopped a few days at Wilton, at a gentleman's house, where we had an introduction; here we had a full opportunity of visiting Salisbury, Lord Pembroke's, &c., not forgetting Old Sarum, Stonehenge. Thou inquirest more particularly about Ross.

We travelled from Monmouth by Ross to Hereford in one day; it is twenty-five miles direct, but we made nearly thirty. Betwixt Monmouth and Ross, we left the road and followed the meandering Wye, surrounded by the most picturesque scenery that can be imagined; there is a plain about 100 yards broad along the Wye at that place, and the banks rise very abruptly from that plain on each side to a great height, interspersed with trees of various kinds, and rocks rising up amongst them, vying with the trees in height. At one place we disputed whether the appearances were natural or artificial; whether the remains of an old castle, or some vagaries of nature; in consequence of which we climbed the hill, and had scarcely satisfied ourselves, when looking round we discovered a profusion of plants we had never before seen, and several of the more rare ones which we had seen. These things took up so much of our time and attention, that if we had met *the Man of Ross* himself we could scarcely have stopped to ask him how he did. We were an hour in Ross, and dined there; it is a neat and pleasant town; we inquired what there was to be seen, and were informed, nothing so remarkable as a view from the churchyard. We went, and were gratified with a sight which immediately suggested to us both the view from Windsor Terrace; it was indeed nearly equal to it. The church stands upon a hill, neat and well built, with a noble spire; the yard, walks, &c., remarkably neat, and fine green turf. Of the alms-house we heard nothing. We walked over the causeway indeed, but knew not that we were upon hallowed ground! till we got to Liverpool. Then we learned that a causeway we remembered very well in coming out of Ross was that in question; it is on the road in a low place, apt to be flooded, where a foot walk is raised a great

height, I think, by one or more arches, and paved for about 100 yards. I remember when we passed it, a horseman chose to ride over it, and leapt the bar at the end. Were I to go again, I should wish to spend more time at Ross. I do not mean so much to compliment Eaglesfield as to decry Montgomery in what I said. When one goes to a *county* town, and has to look at every house side for a painted board, and when they have found one, they have not *one* spare bed for a *couple* of travellers, it is not to be expected that visitants will go away with a good report. With respect to Wales in general, thou thinkest I am too severe. In Cumberland every other man one meets has a little estate which he cultivates himself, and enjoys the produce; but in Wales they are *all* labourers, the masters are never seen, they are not in the country. How can a "Philanthropic Philosopher" observe these things without emotion?

I paid a visit this winter to Kendal, and to my esteemed friend John Fell of Ulverston, in whose family, consisting of himself, wife, daughter Margaret, and a relation of theirs, I spent four or five days with great satisfaction. I also spent a day or two at Lancaster for the first time since the death of my fellow-traveller. His amiable sister Hannah has never been well since.

I must now conclude, with my continued respects for cousin Ruth and thyself; and the remembrance of my other friends at Eaglesfield is grateful.—I remain, &c., JOHN DALTON.

P.S.—As one of the committee of Friends' school here, I may observe, that we are yet in want of a master, but expect to agree with one shortly.

In the midst of his scientific pursuits, upon which his energies were daily concentrated, Dalton had the faculty of unbending himself in the society of women, and could enter with zest into their homely wants and pursuits, especially when they relished his conversation and offered no objection to his use of tobacco. The purport of the subjoined letter was to get a small spinning-wheel from Cumberland, but it

comprises other subjects worth noting, both as to his social enjoyments and the historical relations of Manchester.

MANCHESTER, 2 *mo.*, 20*th*, 1800.

DEAR COUSIN,—I do not know whether I ought not to apologise for troubling thee so often on matters of business; but not knowing exactly Isaac Harris' address, and wanting simply to tell him that another wheel [small spinning-wheel] is wanted, as like the former as may be, I thought it would be no great inconvenience for thee to inform him. The one we have got gives great satisfaction, and I have the pleasure of seeing it in motion, whilst I smoke my pipe, two or three evenings in the week, though it is more than half a mile from my lodgings. It reminds me of some pleasant evenings spent at Eaglesfield in times of old, and prevents me repining at the loss of them. The second is for two younger sisters who will be anxious for its speedy arrival.

The high price and scarcity of flour is a serious calamity with you, I suppose, as well as with us; it is no trifling matter to supply our market with 10,000 stone per week.

In the literary and philosophical way I suppose thy curiosity will be subsided a good deal. The Literary and Philosophical Society of this place (a concern wholly independent of the academical institution I am in) have lately erected, for themselves to meet in once a fortnight, a very elegant building. The members are about 70, resident in Manchester. I am just making out a statement of the expenditure: the building has cost us about £800, and the furniture of the room to meet in upwards of £100. It is said to be much more elegant than that of the Royal Society. I read two papers last winter; one relative to an essay of Count Rumford; the other an inquiry whether the rain is sufficient to supply springs and rivers, and afford enough of water besides for the purposes of vegetation; which I endeavour to show is fact. The rivers of England and Wales I calculate equal to nine times the Thames, and that they all together take off little more than one-third of the water that falls in rain.

I almost forgot to say anything of my fellow-traveller; the truth is, I have not seen him for two months; he is busy and I am busy, and if we meet it is only to have a hearty shake of hands.

We have had a severe cold or influenza here lately, which most people have had. I never remember to have been so ill in my life; was confined to the house for several days. It was attended with an extraordinary degree of languor, along with other symptoms of a cold.

I must conclude with my kind love to cousin Ruth and to friends, and remain thy affectionate cousin, JOHN DALTON.

To ELIHU ROBINSON,
Eaglesfield, near Cockermouth.

Here is a letter explanatory of his Grammar, and containing good news as to the number of his pupils, and his fees as a teacher: "not yet rich enough to retire":—

MANCHESTER, 3 *mo.*, 22*d*, 1802.

DEAR COUSIN,—Having an opportunity to write thee by a friend, I am unwilling to neglect it, though my time is very limited. Thy favour of the 2d of 1 mo. came duly. I am obliged to thee for thy remarks on my "Grammar," and do not differ so widely from thee in regard to Fisher's; for, I think upon the whole, it is as good as any that has succeeded it; but at the same time I think they are all very bad, or I should not have been at the trouble to write one principally for my own use. I am now in the practice of teaching it, and find it the most intelligible to my young people of any they have met with.

I believe it has not yet been reviewed; whether through the negligence of my bookseller or the reviewers, I know not, and have been too busy to mind it till lately: I wrote my bookseller a few days ago on the subject. Some of my friends gave Morris Birkbeck a copy, and he did not like it at first; but upon a second perusal he became a convert. I have seen Wilson's edition of Fisher, but do not recollect particulars. It certainly makes against an *elementary* treatise, and especially one on *grammar*, if the language be not intelligible. It seems the expression, "Diversions of Purley," * is not easily under-

* This must refer to John Horne Tooke's publication in 1786, of "Diversions of Purley," the latter of which names was given to the work in compliment to the residence of his friend, Mr Wm. Tooke.

stood without some notes *critical* and *explanatory.* Please then to take the following :—

Explanatory Note.—Purley is the name of the house or place where the author resides ; it is noted by the author as being the residence of Bradshaw, the President on King Charles's trial. It is about a mile from Wandsworth, Surrey.

Critical Note.—The title "Diversions" seems very inappropriate to a learned dissertation on the origin and structure of language ; perhaps it was a little vanity in the author to denominate what some people would think very laborious investigations by the name of diversions. However that might be, his Greek title ['Επεα Πτεροεντα] is appropriate enough, signifying "Winged Words," to denote the speed with which language conveys ideas.

My Academy has done very well for me hitherto. I have about eight or nine day pupils at a medium, at ten guineas per annum, and am now giving upwards of twenty lessons per week, privately, at two shillings each besides. [I] am not yet rich enough to retire, notwithstanding.

With my kind love to cousin Ruth, thyself, and other friends, I remain, in haste, JOHN DALTON.

To ELIHU ROBINSON.

On November 12th, 1802, Dalton read to the Literary and Philosophical Society an "experimental inquiry into the proportion of the several gases or elastic fluids constituting the atmosphere." (Memoirs, Second Series, vol. i. p. 244). These he ascertained by weight to be:

Azotic gas	75·55
Oxygenous gas	23·32
Aqueous vapour	1·03
Carbonic acid gas	·10
	100·00

This essay is of no small interest as one of his earliest contributions to pure chemistry, and it

assumes historic value as announcing in the combinations of oxygen and nitrous gas (now called nitric oxide gas) the first example of the law of *multiple* proportions. In describing the various eudiometrical processes then in use, he preferred the nitrous gas method. The oxygen contained in 100 measures of common air, he found, would combine, in a narrow tube, with 36 of pure nitrous gas, forming nitr*ic* acid; or with 72, in a wide vessel, forming nitr*ous* acid. The residuum in each experiment was 79 or 80 measures of pure nitrogen gas. "These facts clearly point out the theory of the process: the elements of oxygen may combine with a certain portion of nitrous gas, or with twice that portion, but with no intermediate quantity." His general conclusion from his own experiments, and those of Davy, was, that 100 volumes of air consist of 79 of nitrogen and 21 of oxygen, numbers nearly accordant with the later ones of Dumas.

He was strongly of opinion that the proportions of these gases would differ at various elevations; and that at the height of Mont Blanc the ratio of oxygen gas to nitrogen, in a given volume of air, would be nearly as 20 to 80; but the observations of Gay Lussac showed the relative composition of air brought from an elevation of four miles, to be the same as that at the earth's surface.

This subject was one of lasting interest to Dalton, and his more mature views will fall better under consideration here than in a subsequent page. In his Memoir, "On the Constitution of the Atmosphere," published in the *Philosophical Transactions* for 1826, Part ii. p. 174, he recurs to the question, "Whether

the uniform diffusion of elastic fluids through each other is occasioned by the repulsion of the elementary particles of the same kind, which appears to force them through most bodies, as well solid and liquid as aërial, except glass and the metals; or whether it is caused by attraction or chemical affinity:" and adds, "I have long been inclined to adopt the former notion, as most consistent with the phenomena." It is less needful to dwell on the theoretical considerations adduced in this Memoir, as a sequel to it, recording his final opinions, was read on June 15th, 1837, and published in the *Philosophical Transactions* of that year (x. p. 347). He describes his experiments on air obtained by himself from the summit of Helvellyn, about 3000 feet above the level of the sea; by a friend, at various stations in Switzerland, about 6000 feet; and by Mr Green, in a balloon, at elevations of 9600 feet and 15,000 feet. This last air yielded 20.59 and 20.65 oxygen per cent.; while air collected in Manchester the same day gave 20.95 on the average of five experiments. He concluded that "in elevated regions the proportion of oxygen to azote is somewhat less than at the surface of the earth, but not nearly so much as the theory of mixed gases would require; and that the reason for this last must be found in the incessant agitation in the atmosphere from winds and other causes." Dr Henry found in Dalton's letter-book (February 1836) the following notice on atmospheric air—"Will it not be thought remarkable that in 1836 the British chemists are ignorant* whether *attraction*, *repulsion*, or *indifference* is

* This note of Dalton's would show that he felt as dissatisfied with

marked when a mixture of any proportions of azote and oxygen is made?"

That which Dalton conceived within the scope of British chemists in 1836, is still a matter *sub judice;* but what evidence is adduced, and notably by Gay Lussac, Regnault, and Bunsen, is in favour of the variation in the composition of the atmosphere at all attainable elevations as regards oxygen and nitrogen being very small, and not exceeding the slight changes which are noticed at the same spot on different days.

He read an essay of considerable interest on January 28, 1803, "On the Tendency of Elastic Fluids to Diffusion through each other." He took two phials, filled with different gases, and connected them together by a glass tube 10 inches long and $\frac{1}{20}$ inch bore. In all cases, the heavier gas was in the under phial; yet, after the lapse of a certain time, the gases were uniformly diffused through each other in both phials. Thus he proved that elastic fluids of different specific gravities, if once diffused through each other, do not separate by long standing, so that the heaviest is found lowest, but remain in a state of uniform and equal diffusion. These phenomena of diffusion were afterwards investigated very thoroughly by Professor Graham, who determined the beautiful law that the rate at which gases diffuse is inversely as the square root of the densities of the gases.

The year 1803 showed a large amount of good and

the knowledge then extant on the conditions of the atmosphere, as he was with the ideas generally prevalent regarding the height of the aurora borealis, to which reference has been made in p. 95 of this Memoir.

original work done by Dalton, and was probably the most prolific in scientific gains of any year that he had spent in Manchester from 1793 to 1803. Befitting the close of this first decennial period, so truly fertile in the growth of great ideas that tended to elevate the author to high rank among the *savans* of Europe, Dalton read (October 21, 1803) a paper "On the Absorption of Gases by Water and other Liquids," which contains the first announcement of his discovery of the laws of combining proportion and the germ of the Atomic Theory. After stating the laws which he had found to regulate the absorption of gases by water, he contends that gases such as oxygen, nitrogen, carbonic acid, &c., when in aqueous solution, are mechanically mixed with water, not chemically combined with it—a view that has not met with general approval. He compared his gas dissolved in water to a pile of shot,—"a particle of gas pressing on the surface of water is analogous to a single shot pressing upon the summit of a square pile of them;" and to make this distinct to his readers, inserted an engraving of a pyramidal pile of balls left unshaded, with a dark ball surmounting the apex. "The lower globes are to represent particles of water, the top globe a particle of air resting on particles of water." Two other engravings show a "horizontal view of air in water," and a "profile view of air in water," in which dots and crosses are taken to represent particles of air, with spaces of water between them.

These engravings are viewed by Dr George Wilson, "as affording additional illustrations of the

hold which a belief in the atomic constitution of matter had taken of Dalton's mind, and the use which he made of it in discussing purely physical problems (or, at least, what he considered such), before he had occasion to apply it to chemical questions at all."

The concluding paragraph of the Memoir on "Absorption," is the first clear indication of his greatest discovery, and is best introduced in his own words, some of which I have taken the liberty to place in italics as worthy of special notice :—

"The greatest difficulty attending the mechanical hypothesis arises from different gases observing different laws. Why does water not admit its bulk of every kind of gas alike? This question I have duly considered, and though I am not yet able to satisfy myself completely, I am nearly persuaded that the circumstances depend upon the weight and number of the ultimate particles of the several gases, those whose particles are lightest and single, being least absorbable, and the others more, according as they increase in weight and complexity. *An inquiry into the relative weights of the ultimate particles of bodies is a subject, as far as I know, entirely new. I have lately been prosecuting this inquiry with remarkable success.* The principle cannot be entered upon in this paper; but I shall just subjoin the results, as far as they appear to be ascertained by my experiments."

Then follows a Table (read October 1803, but published November 1805) of the Relative Weights of the Ultimate Particles of Gaseous and Other Bodies :—

Hydrogen, . . .	1·	Nitrous oxide, . .	13·7
Azote, ...	4·2	Sulphur, . . .	14·4
Carbon, . . .	4·3	Nitric acid, . . .	15·2
Ammonia, . . .	5·2	Sulphuretted hydrogen,	15·4
Oxygen, . . .	5·5	Carbonic acid, . .	15·3
Water, ...	6.5	Alcohol, . . .	15·1
Phosphorus, . . .	7·2	Sulphurous acid, . .	19·9
Phosphuretted hydrogen,	8·2	Sulphuric acid, . .	25·4
Nitrous gas, . . .	9·3	Carburetted hydrogen, .	6·3
Ether, ...	9·6	Olefiant gas, . . .	5·3
Gaseous oxide of carbon,	9·8		

"Such, then," writes Dr Wilson, "were the steps by which Dalton was conducted to the discovery of the laws of combining proportions. He was testing, by experiment, the truth of a hypothesis as to the cause of the specific solubility of gases in water, which proved in the end to be quite untenable; but, like Columbus, who missed an El Dorado but found an America, he discovered something better. From what Dr Thomson tells us, he was struck by observing that the quantity of hydrogen in fire-damp is exactly twice that in heavy carburetted hydrogen, the quantity of carbon being the same in both. His constant reference of the properties of masses to those of their smallest molecules, led him at once to connect these proportions in which the carbon and hydrogen occurred, with the relative weights of their attracted particles." Dr Wilson supposes that Dalton reasoned thus: "Hydrogen and carbon are made up of particles which have different weights, the carbon atoms being all six times heavier than the hydrogen ones; but if hydrogen and carbon have atoms differing in relative weight, oxygen, nitrogen, and every other elementary substance will have atoms differing in relative weight also; and these may be ascertained

by finding the relative weights according to which the masses made up of them combine with each other. To Dalton's mind, fitted, as it were, already with the conception of everything consisting of atoms, it was only necessary to introduce the additional idea of those atoms differing in relative weight, and all the laws of combining proportion rose at once into view. He was gifted with a bold, self-reliant, far-glancing, generalising spirit, and the researches he had long been prosecuting had doubtless strengthened greatly that faith in the uniformity of Nature's laws, which we all inherit as an essential part of our mental constitution. We may believe that, without an effort, and almost instinctively, he would infer that if hydrogen followed a law of multiple proportion in its higher combinations with carbon, a similar relation would be found to hold in every case where the same elements united to form more than one compound."

Dalton's views of chemical combination, including both the facts and the hypothesis which expressed and explained them, are generally known as his "Atomic Theory."

CHAPTER IX.

A SKETCH OF THE ATOMIC THEORY FROM THALES TO SIR ISAAC NEWTON.

> "For hot, cold, moist, and dry, four champions fierce,
> Strive here for mastery, and to battle bring
> Their embryon atoms."—MILTON.

COEVAL with the manifestation of the reasoning faculties—that far and pre-historic past of man's development—the constitution of the earth and its different aspects and surroundings would hardly fail to excite the imagination of the denizens of the wilde; and, in the course of time, natural phenomena would offer large discussion to the better endowed of the race. A recognition, however faint, of the external world and its living beings, would gratify the dawning mind, and vie in interest with the contemplation of the gods, whose attributes were not seldom associated with both human and terrestrial agencies. In scanning these agencies endless speculations arose, as fanciful in tone as they were ephemeral in duration; each new thought proving as baffling as its predecessor in the attempted solution of the great problem:—What is the constitution, the ultimate composition, or real nature of matter itself?

The bold expounders of the cosmogony undertook an arduous task, and as their efforts to unravel the in-

tricacies of nature often failed, they found it convenient to follow the example of the theogonists, and shelter their ignorance under the shadows of the mythological altars of their age and race—an orthodox mode of treating scientific difficulties that is not without its counterpart in the history of the state churches of these latter days. The progress of knowledge might well be dilatory amid the almost impenetrable mists of superstition in the past, when to-day the cry of "more light" is still so audible among the adepts of science; and this, be it remembered, after eighteen centuries of Christian indoctrination, itself ushered into the world upon a large substratum of man's intellectual gains.

History has made us cognisant of the varied acquirements of the Eastern nations; of the marvellous skill and aptitude of the Egyptians; of the nobler forms of art, the noblest ever vouchsafed to man, being developed *pari passu* with the grandly philosophic aims of the Greeks; of the world-wide dominion and scope of the Romans; of the subtle grasp of the Arabian physicians, and the erudite lore of the schoolmen; all operating more or less in the direction of enlightenment and civilisation. Yet the science of these modern days culling its data from the great stores of evidence of the past, and favoured by novel experimental appliances and methods of inquiry strictly inductive, can lay claim to little more than a firm step on the threshold of discovery.

As of yore, so do enthusiastic minds now look hopefully for still higher revelations in science; and assuredly, if there was ever an epoch in human history marked by bold and progressive lines, and

powers to fathom the arcana of the cosmos, it is the present age that has been blessed, beyond all precedent, by discoveries of overpowering brilliancy and magnitude.

Man looks upon the Earth, its waters and dry land, and admires its meres, its meadows, and its mountains; he soars for miles in its circumambient air; he mines its superficial crust, and fathoms its ocean depths; and everywhere marks a marvellous diversity of form and substance in the stratified rock, the tidal wave, and transparent ether. His admiration is enhanced by contemplating the myriads of organisms in active life, taking their start from the primitive organic cell that in its timely growth and maturity may become shaped into the umbrageous palm or gnarled oak; or find its nidus in the higher organisation of the chimpanzee or cetacea. Yet the organic and inorganic worlds in all their entirety; the blood and the life thereof, as well as the adamantine conditions of inert matter, when subjected to chemical analysis, become resolved into a few primary or elementary substances. They are designated simple or elementary bodies, because they can be shown to exhibit one kind of ponderable matter only, be it light as air, or heavy as lead; for instance, the gases oxygen and hydrogen, or the metals gold and silver, which the chemist has hitherto failed to resolve into more parts or constituents than one.

To-day the chemist assures us of sixty-three elementary bodies—some of them being little heard of, others in vast proportion to the mass; thus four well-known elements in their various compounds,

constitute the whole of the organic kingdom—including all living things flourishing on the earth or in the ocean. Reflecting on the mode in which Nature works, and the few agencies she employs in the formation of the most composite of her structures, it is probable that in the course of time these sixty-three elements may be reduced to a smaller compass, and eventually man, by the aid of a higher science, may realise the grand idea of

One God—one Law—one *Element*.

This word "element" has been in use for thousands of years, bearing, however, a very different meaning to that attached to the term by modern chemists; thus air, water, fire, and earth, were called elements, and in common parlance to-day we hear of the watery or the fiery elements. Now air and water are not primary or elementary in structure, (though they were viewed as such till about one hundred years ago), but, consisting as they do of two or more gaseous substances, belong to the class of bodies designated composite or compound. The chemist has no faith in substances being deemed elementary till his experiments, or processes of reduction, fail to elicit more than one kind of matter from his analyses.

The nature and the number of elementary bodies do not affect this thesis; but rather, having got an unit or element, say oxygen or gold, chlorine or mercury, it behoves us to know the condition of its minutest particle or ultimate form? Is it solid, penetrable, or divisible; and what are its relations and affinities?

It is pretty well established, that with the dawn

of philosophy among the Greeks, if not dating back to the Egyptians, with whom, as far as this narrative is concerned, the Hindoos and Chinese may be historically bracketed, the higher minds of these respective races were divided in opinion, not only as to the character and import of the visible agencies in the cosmogony, but as to the ultimate and invisible or smallest conceivable particles of matter. And the discussion arising thereon has been continued down to our own day without arriving at a determinate or settled conclusion on the subject.

Two theories have long been upheld, and are still current regarding the constitution of matter.

1. According to one class of thinkers, there is no limit to the divisibility of matter, the smallest portion of any substance still consisting of an infinity of parts, which could be rendered distinct if our instruments and senses were capable to the task.

2. The opposing party hold that every material mass in nature is divisible into very minute, indestructible, and unchangeable particles; to which particles the name *Atom*—a Greek term signifying *that which cannot be further cut or divided*—has been given. The preponderance of opinion is in favour of this view, or the atomic constitution of bodies upheld by Dalton, who maintained that all bodies are composed of ultimate atoms, the weight of which is different in different kinds of matter.

The ancients meditated much on *atoms*, the primitive matter or essence of things, mainly, however, from a physical point of view. And though the opinions they advanced were not infrequently shadowed by a fitful intuition, or swayed by a longing to

define the proximate cause or generative principle, that in the beginning of things educed form out of chaos, and life out of inert matter, they were not devoid of significance in the initiatory stages of the science. The pioneers in this path of speculation, along which the Greek minds took foremost rank and action, may be briefly noted.

Thales of Miletus, styled the Father of Greek Philosophy, originated the conception of *water* being the first principle of things, the sole primeval matter that could be rendered by some plastic power into vital organisms, as well as the structureless inorganic. The thought was beautiful, and seemed to flash a significant light over the varied phenomena of nature —water, the essential stimulus to vegetation and animal vitality; the refreshing dew and rains, the rivers and seas, and the pervading element seeking the great and unknown deep.

Then came Anaximenes trying to improve upon Thales, and assigning to *air* the foremost place in his theory of nature, nay, of such value as to be the equivalent of intelligence, if not a kind of deity itself. Thales and Anaximenes were but carrying out the poetic myths of the age, and not altogether without a glimmering of light bearing upon the chemistry of the universe.

A more stable doctrine than the foregoing got promulgated by Pythagoras—the doctrine of the four elements, culled, it is believed, along with his special views of monads, from the land of mystery—Egypt. This dogma found support in the experiment of Empedocles, recorded in page 7. Democritus held by the four elements as evidences of chemical change,

but would revert to the Thalesian view of one true and primitive substance. These varied opinions found disciples in the great men of the epoch. Plato looked to the earth as fixed and penetrable, and differing from fire, air, and water, the transmutable elements. Aristotle held with Democritus in the belief of one radical matter of the universe, and cast some doubts on the four so-called elements; yet history generally associates his name with this *quaternion*, because historians were disposed to approve of the doctrine, and liked a great name to countenance their beliefs.

Now and then in the dark vista of history, a name shines out like Geber, the head of the polypharmists in the eighth century, who held that arsenic, mercury, and sulphur are the elements of all other chemicals, and that they are mutually transmutable into one another. He also believed that his red solution of gold might turn out the veritable elixir of life. Others again reverted to the ideas of the Greeks, with their primal matter, out of which sprang four elements, and sundry secondary and derivative chemical shapes and shadows.

The Hindoos had their own views of the constitution of matter; and in their reasonings upon natural things as springing from four or five elements, they were in the same track as the Greeks. Mr James Mill, in his work on British India, ridicules their views as the offspring of an erratic mind; but Mr Colebrooke ("Daubeny's Atomic Theory," p. 8), citing Kanadi for his authority, shows that they regarded matter as consisting of the smallest possible bodies, or atoms which are indivisible; that the particles of dust seen in a

sunbeam are composed of several of them; that a superior force drew the atoms together; and that the first compound is binary, consisting of two simple atoms, the next compound of three binary atoms, &c.

The most striking fact in favour of the Hindoo philosophy is furnished by Sir William Jones, from the poem of "Shi'ri'n and Ferha'd," or "the Divine Spirit and a Human Soul Disinterestedly Pious."

"There is a strong propensity which dances through every atom, and attracts the minutest particle to some peculiar object; search this universe from its base to its summit, from fire to air, from water to earth, from all below the moon to all above the celestial spheres, and thou wilt not find a corpuscle destitute of that natural attractability; the very point of the first thread in this apparently entangled skein, is no other than such a principle of attraction, and all principles besides are void of a real basis; from such a propensity arises every motion perceived in heavenly or in terrestrial bodies; it is a disposition to be attracted, which taught hard steel to rush from its place and rivet itself on the magnet; it is the same disposition which impels the light straw to attach itself to the amber; it is the quality which gives every substance in nature a tendency toward another, and an inclination forcibly directed to a determinate point."

It would appear that the orthodox priesthood of the Hindoos objected to this atomic doctrine, as too materialistic; the same scruples arose in Greece: and it is doubtful if nineteenth-century England is altogether free of men of professedly philosophic turn, who look harshly upon the carrying out of the atomic doctrines to their fullest extent.

If the Oriental sages recognised the fact of matter being ponderable and permanent, the Greeks, and notably Anaxagoras, Leucippus and Democritus,

inspired by a higher genius that partly uplifted the veil of Chaos, and admitted a designing intelligence or *νοῦς* in the arrangement of matter, were led to the hypothesis of its composition of molecular, or indivisible and indestructible atoms. The speculations of these and other learned Greeks as to the constitution of the universe, show a remarkable coincidence with the views that have been educed from the researches of modern philosophers of our own epoch. Aristotle (Met. I. ch. 4) wrote: "Leucippus and his companion Democritus say that the plenum and the vacuum (or the full and the empty) are elements . . . and that these are causes, as matter, of things which are . . . And they say that different things are produced by the differences as to these; which differences are—I. of form, as A. differs from N; 2. of arrangement, as A.N. differs from N.A; 3. of position, as Z. differs from N." Leucippus looked upon the cosmos as produced by the falling together of small indivisible particles or stones, which he viewed as the principle of things; and which possess a rapid circular motion. Democritus extended the views of his master, and held the atoms to be too small to be visible, yet they were indivisible, impenetrable, and unalterable. As the atoms were infinite in number, the vacuum was infinite in magnitude. From the meeting of atoms in vacuum, sensible qualities of matter arise, *e.g.*, heat, cold, sweetness, colour, which qualities exist only *νόμῳ* (by convention), "only atoms and vacuum really exist." Again, he says, there are various shapes; so everything was referred to atoms, to which simple bodies he gave shape, extension, and force. They were the primary elements, and all things were made up of

them by *configuration*, *combination*, and *position*. Leucippus and Democritus alike held that the number and the shapes of the atoms are both infinite.

Here is presented to us the atomic theory of the Greeks, as laid down by Democritus, and which was further elaborated by Epicurus.

"The atomic philosophy of Epicurus," as sketched by Dr Good in his "Book of Nature," "allows of nothing but matter and space, which are equally infinite and unbounded, which have equally existed from all eternity, and from different combinations of which every visible form is created. . . . Matter, in its elementary state, consists of inconceivably minute seeds, or atoms so small, that the corpuscles of vapour, light, and heat, are compounds of them ; and so solid, that they cannot possibly be broken or abraded by any concussion or violence whatever. The express figure of these primary atoms is various, but not infinitely diversified ; the atoms of each existing shape being infinite or innumerable. . . . .

" When these primary atoms are closely compacted, and but little vacuity lies between them, they produce solids, such as stones and metals ; when they are loose and disjointed, bodies of lax texture, as wood, water, and vapour.

" The world, thus generated, is perpetually sustained by the application of fresh tides of elementary atoms, flying with inconceivable rapidity through infinite space, and occupying the posts of those that are perpetually flying off. Yet nothing is eternal or immutable, but these elementary atoms themselves.

" Space is infinite, material atoms are infinite, but the world is not infinite. This, then, is not the only world, nor the only material system that exists. The cause that has produced this visible system is competent to produce others ; it has been acting perpetually from all eternity ; and there are other worlds, and other systems of worlds, existing around us."

It has been supposed that the opinions of Democritus were copied from Moschus a Phœnician ; and that the

doctrine of monads advanced by Pythagoras was but the corpuscular atoms of the Egyptians. Pythagoras, according to Aristotle, considered his monads as possessed of size: *τὰς μονάδας ὑπολαμβάνουσιν ἔχειν μέγεθος* (Met. lib. xii. c. 6).

From the axiom that "like can act upon like," Anaxagoras formed his *homœomeriæ* (some attribute the doctrine to Aristotle), that Democritus accepted and extended. There was much of the Democritean theory implied by Anaxagoras in his tenet, that every distinct kind of matter has its distinct shape and weight of particles.

The atomism of Democritus has enjoyed as great historical repute as any scientific theory that ever emanated from the Greeks; and according to my friend, Mr G. H. Lewes, it is one of the profoundest speculations yet reached by human subtlety. Leibnitz, belonging to our modern school of philosophers, was led to a doctrine essentially similar: his celebrated monadologie is but atomism with a new terminology. Leibnitz called his monad a *force,* which to him was the *prima materia.*

The admirers of Democritus will have it that he saw an Intelligence in the "formative principle" of things; and that his atomism, developed two thousand five hundred years ago, prefigured the *corps de doctrine,* established by John Dalton in the nineteenth century of the Christian era, and now accepted as the groundwork of a true chemistry. Admitting to the full the admirable conception of the renowned Democritus, it should be borne in mind that the modern atomic theory sets forth the *Law of definite proportions,* whilst the ancient theory, as Lewes has so well ex-

pressed, "is merely the *affirmation of indefinite combinations.*"

In further evidence of the keen grasp of the Greek philosophers, Berzelius, the famous Swedish chemist, in his paper on "Proportions Determinate," quotes from Philo, who in his collection of the choicest philosophical ideas of his time, says:—*Πάντα θεὸς μέτρῳ, καὶ ἀριθμῷ, καὶ σταθμῷ διέταξε.* (God ordered all things by measure, number and weight.)

Lucretius, in his "De Rerum Natura," eloquently introduced the philosophic views of Epicurus to the Roman world. A few excerpts from the excellent translation of Lucretius by Professor H. A. J. Munro, M.A., 1st ed., Cambridge, 1864, seem desirable.

"Bodies again are partly first-beginnings of things, partly those which are formed of a union of first-beginnings. But those which are first-beginnings of things no force can quench; they are sure to have the better by their solid body; although it seems difficult to believe that aught can be found among things with a solid body—for the lightning of heaven passes through the walls of houses, as well as noise and voices; iron grows red hot in the fire." &c . . . "Attend till we make clear in a few verses that there are such things as consist of solid and everlasting body, which we teach are seeds of things and first-beginnings, out of which the whole sum of things which now exists has been produced." (Bk. i. 483–490 and 500–502.)

"Again, unless matter had been eternal, all things before this would have utterly returned to nothing, and whatever things we see would have been born anew from nothing. But since I have proved above that nothing can be produced from nothing, and that what is begotten cannot be recalled to nothing, first-beginnings must be of an imperishable body, into which all things can be dissolved at their last hour, that there may be a supply of matter for the reproduction of things. Therefore first-beginnings are of solid singleness, and in no other way can

they have been preserved through ages during infinite time past in order to reproduce things." (Book i. pp. 540–550.)

"Moreover, while the bodies of matters are most solid, it may yet be explained in what way all things which are formed soft, as air, water, earth, fire, are so formed, and by what force they severally go on, since once for all there is void mixed up in things. But, on the other hand, if the first-beginnings of things be soft, it cannot be explained out of what enduring basalt and iron be produced; for their whole nature will utterly lack a first foundation to begin with. First-beginnings, therefore, are strong in solid singleness, and by a denser combination of these, all things can be closely packed and exhibit enduring strength." (Book i. 565–576.)

"First-beginnings, therefore, are of solid singleness, massed together and cohering closely by means of least parts, not compounded out of a union of those parts, but rather strong in everlasting singleness. From them nature allows nothing to be torn, nothing further to be worn away, reserving them as seeds for things. Again, unless there shall be a least, the very smallest bodies will consist of infinite parts." . . . . "Therefore, between the sum of things and the least of things, what difference will there be? There will be no distinction at all; for how absolutely infinite soever the whole sum is, yet the things which are smallest will equally consist of infinite parts." (Book i. 609–622.)

"The first-beginnings of things have different shapes, but the number of shapes is finite." (Book ii. 479–80.)

"Since a fixed limit has been assigned to things which bounds their sum on each side, you must admit that matter also has a finite number of different shapes." (Book ii. 512–514).

Lucretius condemned those who advocated the opinion that the primary matter of all things rested on either fire or air, water or the earth. His speculations on the mode by which the primordial elements are acted upon by force, are less clearly expressed. He gives his atoms various shapes and sizes, but does

not admit of their being sentient, or they would "produce nothing but a crowd and multitude of animals."

It is curious to observe his approximative aim to the atomic theory, and not less his tentative efforts to elucidate the mode in which the primordial elements being "not sentient," are acted upon by forces throughout the whole—a problem of much interest and somewhat akin to the determination of force, at present agitating the physicists of Europe.

Cicero in his "De Natura Deorum," reasoning on the rotundity and apt analogies of the celestial orbs to natural history entities, and the construction of the visible earth, would seem to have fallen upon many lines of thought previously traversed by the Greeks, and adorned by his friend Lucretius, from whose poem several quotations have been made. He was probably incited to this by his love of Athens, and his friendship, as Munro says, with the leading Epicureans, both Greek and Roman, to one of whom, Philodemus, as it now appears from the Herculanean fragments recently published, he was greatly indebted in his "De Natura Deorum."

As the ancient schools of philosophy gradually waned and sank below the horizon, there arose, and among the Arabians chiefly, the mystical arts shadowy of themselves, and not less shadowed by spiritual authority and interference. Of these arts alchemy was most prominent, and its cultivators seem to have blended what knowledge had come down to them from the Alexandrian school, and a portion of the Aristotelian philosophy, with the results of their own operations in the laboratory—it being as much a matter of policy in the East to be able to cite great

names in support of new doctrines, as it is the fashion of Western nations to hold by precedent and privilege in the defence of the *status quo* of governmental rule.

If the masters in alchemy, and chief men of the Middle Ages, gave the doctrine of atoms a place in their speculations regarding matter and the cosmos, they do not appear to have enlarged the thesis, or to have advanced beyond the doctrines so classically expressed by Lucretius. Dr Angus Smith has gone carefully over the history of the period, but apparently elicited little more than a confirmation of the belief generally entertained, that the mediæval workers rested their reasonings very much on the existence of four elements, or old Aristotelian dicta, so long viewed by the multitude as infallible. Now and then a ray of light emanated from the dark chambers of these enthusiasts, that partook of novelty rather than logical accuracy, and got shaped into such forms as the "*quinta essentia;*" "specific fermentations;" and the "*materia prima*," the latter tenet being little more than a revival of Plato's πρώτη ὕλη, the primary *hyle*, that might be freely translated as true matter, though others have viewed it as "matter in the abstract."

The fetishisms and national "idols" were not without their visible effect upon the primitive ideas emerging from the chaos of thought, that in time served as modes of interpreting natural phenomena. The mingling of these, and the adoption of a form of theology based on the generative principle that existed in full force in the speculations of the ancients, found illustration in the names of Isis and Osiris, typical of the Alexandrian school of thought, being retained

by alchemy, whilst salt, sulphur, and mercury were connected with the Trinity of Christians.

After the Arabians, Geber, Raymond Lully, Albertus Magnus, Roger Bacon, and Basil Valentine were among the most conspicuous members of the great school of alchemy;* men who, in their practical aims and manipulations of ordinary chemical workings, rendered service to the cause of *qualitative* chemistry, as long as they confined themselves to the experimental path; but as they were led away by their metaphysics and current theological opinions, they rendered but inadequate help to the cause of *quantitative* chemistry.

Comte has said that there must be three principal epochs in the growth of every science, and of all the sciences together: "the childish religious, the boyish metaphysical, and the manly positive of development." Dr Samuel Brown would have preferred to distinguish these three ages as the superstitious, the fictitious, and the real. In the dreamy age of chemistry, theories in abundance were being offered on the ultimate composition of matter, chiefly in an abstract form, or based on the Pythagorean or Aristotelian methods. The professed cultivators of science were more disposed to give airy attitudes to

* Dr Angus Smith cites Palissy, the well-known potter of the 16th century, as taking part in the discussion of the great problem of the day, and actually siding with the notions expressed by Thales, the first of Greek reasoners, a fact that proves him to be less of a philosopher than a potter. Böttcher was wiser, he stuck to his alchemy, and though he failed to make gold, he made the best of Dresden porcelain. Of him it was said:

> "Ye heavens, alchemy has won my votes,
> A goldmaker's changed to a maker of pots."

Philosopher John triangled! or "dephlogisticated," and nearly "Sir Roger de Coverleyed" by "the handsomest woman in Manchester," can only be credited by sober friends on perusing his own narrative of this delicate affair. The untoward symptoms marking his captivity or bondage may seem a little peculiar.

It seems that another of your maids is become mistress—a good omen for the next, whoever she may be. Methinks there may be a question started from some side of the fire when this is read—" I wonder whether John is going to marry yet, or not?" I may answer that my head is too full of triangles, chymical processes, and electrical experiments, &c., to think much of marriage. I must not, however, omit to mention that I was completely Sir Roger de Coverleyed a few weeks ago.

The occasion was this: being desired to call upon a widow, a Friend, who thought of entering her son at the academy, I went, and was struck with the sight of the most perfect figure that ever human eyes beheld, in a plain but neat dress; her person, her features, were engaging beyond all description. Upon inquiry after, I found that she was universally allowed to be the handsomest woman in Manchester. Being invited by her to tea a few days after, along with a worthy man here, a public Friend [a Quaker minister], I should have, in any other circumstances, been highly pleased with an elegant tea equipage, American apples of the most delicious flavour, and choice wines, but in the present these were only *secondary* objects. Deeming myself, however, full proof against *mere beauty*, and knowing that its concomitants are often ignorance and vanity, I was not under much apprehension; but when she began to descant upon the excellence of an exact acquaintance with English grammar and the art of letter-writing; to compare the merits of Johnson's and Sheridan's dictionaries; to converse upon the use of dephlogisticated marine acid in bleaching; upon the effects of opium on the animal system, &c., &c., I was no longer able to hold out, but surrendered at discretion. During my *captivity*, which lasted about a week, I lost my appetite, and had other symptoms of *bondage* about me, as incoherent discourse, &c., but have now happily regained my freedom.

Having now wrote till I have tired my hand, and probably thine eyes in reading, I shall conclude with my love to cousin Ruth and thyself, and to all inquiring friends,

JOHN DALTON.

If Dalton could afford to treat his relations to the fascinating widow in a vein of facetiousness, it was far otherwise with his pen, when the object of his admiration was worthy of his more thoughtful hours. Little demonstrative in any direction outside his own laboratory, he was not without the higher sensibilities of our nature that make the society of women of amiability and mental culture highly enjoyable. In his journeys to Cumberland, he used to pay a visit to a Friend in Lancaster, who had two daughters of both of whom he spoke very highly; but Hannah was evidently his favourite, of whom he writes in the following enthusiastic terms to his brother, September 15, 1796. Considering the high qualifications of the lady, it is to be regretted that Dalton's means were too limited to enable him to marry, or there might have been "a wedding of it," with probably blissful issue to posterity.

"I may here observe that it has been my lot for three years past to be daily gaining acquaintance of both sexes. I have consequently had opportunities of estimating and comparing characters upon a pretty extensive scale. Since my first introduction to ———, twelve months ago, I have spent a day or two with them at six different intervals, with the highest satisfaction, as I never met with a character so finished as Hannah's. What is called strength of mind and sound judgment she possesses in a very eminent degree, with the rare coincidence of a quick apprehension and most lively imagination. Of sensibility she has a full share, but does not affectedly show it on every trivial occasion. The sick and poor of all descriptions are her personal care. Though undoubtedly accustomed to grave and serious reflections, all pensiveness and melancholy are

banished from her presence, and nothing but cheerfulness and hilarity diffused around. Her uncommon natural abilities have been improved by cultivation, but art and form do not appear at all in her manner—all is free, open, and unaffected. Extremely affable to all, though every one sees and acknowledges her superiority, no one can charge her with pride. She is, as might be expected, well pleased with the conversation of literary and scientific people, and has herself produced some essays that would do credit to the first geniuses of the age, though they are scarcely known out of the family, so little is her vanity. Her person is agreeable, active, and lively. She supports conversation, whether serious, argumentative, or jocular, with uncommon address. In short, the *tout ensemble* is the most complete I ever beheld. Next to Hannah, her sister Ann takes it, in my eye, before all others. She is a perfect model of personal beauty. I do not know one that will bear a comparison with her in this respect, at least in our society. With abilities much superior to the generality, she possesses the most refined sensibility, but in strength of mind and vigour of understanding must yield to her elder sister. I dwell with pleasure upon the character of these two amiable creatures, but would not have thee communicate my sentiments to others."

In the journal of a tour in the previous year, when he first became acquainted with this lady, he thus deseribes a walk in her company up the river Lune, as far as Horton:—

"The pleasantness of the evening, the delightful scenery of the country, added to the amiable softness, vivacity, and good sense of our female companion, made it one of the pleasantest walks I ever enjoyed." And again he quaintly remarks :—"In going to a tea-party we were introduced by our fair companion to the hospital for old maids, and saw one of no very alluring aspect. Oh what a contrast!"

It is not improbable that his intercourse with the pretty Friends of Lancaster gave an impulse to his æsthetic sensibilities, that found occasional pleasure in cultivating the muse—

> "Never durst poet touch a pen to write,
> Until his ink were temper'd with love's sighs;"

for, notwithstanding his bucolic and Quaker associations, and the general absence of social opportunities, he had a love of melody, and in listening to his favourite airs would appear more or less spellbound. His "Stanzas Addressed to an Æolian Lyre" have been cited as his best attempt at versification. They are as follows :—

STANZAS ADDRESSED TO AN ÆOLIAN LYRE.

Far from the noisy dissonance of strife,
  From war's dire clarion, boding vengeful ire,
Here let me spend one vacant hour of life,
  To sing thy well-earned praise, melodious Lyre !

When thy soft airs first touched my ravished ear,
  My heart accorded to the tender strain ;
Now gently swelling, called forth pity's tear,
  Now languished, pining, for the love-sick swain.

To every tender feeling of the soul,
  A kindred tone the various breeze excites ;
The enchanted heart yields to the mild control,
  And sweetly banquets on thy soft delights.

At times the notes with gentle zephyrs rise,
  And trembling touch the chord of fond desire,
Now mingling, breathe in soft, responsive sighs,
  Then fluttering, fall, and with the gale expire.

Again the slowly-rising notes assail—
  As if some tender maid, unseen, unknown,
Sighed for neglect—yet tuneful, swelled the gale,
  To melt the unfeeling heart with sorrow's plaintive moan.

If e'er a breast was by soft passion moved,
  If e'er it felt love's sympathetic fire,
With mine thy strains it cordially approved,
  And breathed in chorus to thy praise, sweet Lyre !

A sudden gust now sweeps thy trembling strings—
  What wild luxuriance undulates the air !

The swell majestic all its grandeur brings,
  And dying gales their softer tribute bear.

To yonder copse why should I anxious rove,
  To hear its songsters hail the new-born day?
Why pensive court the music of the grove?
  Thy charming airs surpass their sweetest lay.

When vernal showers refresh the parched vale,
  And Flora's train in richest hues appear,
Not more their varied tints the eye regale,
  Than thy ecstatic notes delight the ear.

Should adverse winds the ruffled soul assail—
  Impassioned looks the rising storm presage—
Thy soothing airs, mellifluous, cannot fail
  To calm each ranc'rous passion's keenest rage.

When nature bids the busy world to close,
  And silence reigns, obedient to her power,
Thy grateful murmurs, lulling to repose,
  Beguile the solemn gloom of midnight hour.

His description of Hannah's personal charms showed him to possess a larger share of the imaginative faculty than was generally assigned to him by his friends. That he was fully alive to the beauty of natural scenery may be gathered from the following extract from his Journal of August 22, 1796:—

"We had a pleasant ride from Kendal, for eight miles, when the grand scenery of the Lakes opened upon us, with full force; the head of Windermere, and about half of the lake, with the surrounding hills, skirted with wood, formed a fine and capacious amphitheatre, which we had in view, more or less, till we arrived at Lowwood. Drank tea there, and immediately after took a boat out to a central part of the lake, when we beheld the sun descending below the summit of Langdale Pikes, whilst its rays still continued to gild the delightful landscape on the

opposite shore. . . . Came off the lake; then proceeded to Ambleside, winding round the still lake by twilight. Went out about ten to view the night scene; the atmosphere was as clear as possible; Jupiter and the fixed stars shone with uncommon splendour, and suggested an unusual proximity. The moon, risen, but not above the mountains, cast a glimmering light upon the rocky hills just opposite, and produced a fine effect. These circumstances, together with the awful silence around, would have persuaded us we had been transferred to some other planet."

John Dalton was thirty years of age before he gave any direct or special attention to chemistry, and his first awakening arose from attending a course of lectures on the subject, delivered by Dr Garnet at Manchester. Though versed in experiments on natural philosophy, he saw the advantage of the varied and attractive illustrations of the chemist in obtaining the approval of popular audiences; and wishing to utilise his knowledge, wrote to his brother in June 1796, that he had some thoughts of delivering a course of lectures at Kendal that summer, including six on physics and six on chemistry. "Twenty subscribers at half a guinea would be a sufficient inducement to commence." Here it is seen that the sum of ten guineas was all he aimed at for twelve lectures to be delivered at Kendal, two days' journey from Manchester, and with the probability of having to purchase new apparatus, chemicals, and other *adjuvantia.*

After an interval of nearly five years (his essay on Colour-blindness being read in October 1794), Dalton made his second communication to the Philosophical

Society, entitled—"Experiments and Observations to determine whether the Quantity of Rain and Dew is equal to the Quantity of Water carried off by the Rivers, and raised by Evaporation: with an Inquiry into the Origin of Springs." Read March 1, 1799 (Memoirs, vol. v. p. 346).

As a matter of supposition rather than evidence, Dalton concluded in favour of their equiponderance; the more valuable part of his essay contains his first distinct enunciation of the theory of aqueous vapour.

"1. That aqueous vapour is an elastic fluid *sui generis*, diffusable in the atmosphere, but forming no chemical combination with it.

"2. That temperature alone limits the maximum of vapour in the atmosphere.

"3. That there exists at all times, and in all places, a quantity of aqueous vapour in the atmosphere, variable according to circumstances."

Count Rumford having attempted to show "that water, and by analogy, all other fluids, do not transmit heat in the manner that solids do; but circulate it solely by the internal motion of their particles," Dalton (April 12, 1799), read to the Philosophical Society an essay on the "Power of Fluids to Conduct Heat" (Memoirs, vol. v. p. 373), based on numerous experiments, and calculated to affect the accuracy of the Count's conclusions. Dalton's method of inquiry was original, and in writing to his brother, March 28, 1799, he says:—I have lately been making some curious experiments on the congelation of water in certain circumstances. I have cooled it down to 5° or 6° without freezing, by putting it into a thermometer tube. I find it also impracticable to freeze it in such circumstances

above 15° or 20°; when it does freeze it is instantaneous, and the liquor shoots up the tube as if ejected by a syringe, and often bursts the tube with a report."

At first he supposed the degree of greatest condensation of water to be at 42° Fahrenheit; that water expands below 42° exactly as it does above—namely, according to the number of degrees. Afterwards he found it needful to correct many of his numerical results, and shifted his ground from 42° to 36° and 38° as the point of greatest condensation of water. To-day chemists accept Messrs Playfair and Joule's determination of 39·101° Fahrenheit.

In May 1800, Dalton was elected Secretary to the Literary and Philosophical Society of Manchester, in the place of Dr William Harvey. This office he retained until the year 1808, when he was made Vice-President in the room of Dr Roget.

In 1817 he was raised to the highest dignity in the Society, and continued to occupy the President's chair during the remainder of his life. The Society practised a generous liberality towards Dalton, who contributed so largely to its fame, nay, European reputation, by permitting him to occupy one of the lower rooms of the Society-house in George Street as a study and a laboratory.

He conferred honour on his secretaryship on June 27, 1800, by reading to the Society, "Experiments and Observations on the Heat and Cold produced by the Mechanical Condensation and Rarefaction of Air" (Memoirs, vol. v. p. 515).

He endeavoured to show "that the capacity of a vacuum for heat is less than an equal volume of atmospheric air, and that the denser the air is, the

less is its capacity for heat," indicating a mode of ascertaining "the absolute capacity of a vacuum for heat," and "likewise the capacity of the different gases for heat by a method wholly new; but this must be left to future investigation." Dalton found that gases expand 1-10th of their volume, nearly for 50° of heat, or nearly 1-500th of their bulk; and at a later period of his life again took up the subject.

In October 1801, he read to the Literary Society the following memoirs: "Experimental Essays on the Constitution of Mixed Gases; on the Force of Steam or Vapour from Water and other Liquids in different Temperatures, both in a Torricellian Vacuum and in Air; on Evaporation; and on the Expansion of Gases by Heat" (Memoirs, vol. v. p. 335).

He begins by saying, "The progress of philosophical knowledge is advanced by the discovery of new and important facts; but much more when those facts lead to the establishment of *general* laws. . . . In the train of experiments lately engaging my attention, some new facts have been ascertained, which, with others, seem to authorise the deduction of general laws, and such as will have influence in various departments of natural philosophy and chemistry." Contrary to what might have been expected of Dalton, he propounded those general laws before citing the experiments upon which they were obtained. However, he denied having made the experiments in support of any preconceived theory; and remarked "on the contrary, the first-laid, which is as a mirror, in which all the experiments are best viewed, was *last* detected, and after all the particular facts had been previously ascertained."

1. When two elastic fluids, denoted by A and B, are mixed together, there is no mutual repulsion amongst their particles; that is, the particles of A do not repel those of B, as they do one another. Consequently the pressure or whole weight upon any one particle arises solely from those of its own kind.

2. The force of steam from all liquids is the same, at equal distances above or below the several temperatures, at which they boil in the open air; and that force is the same under any pressure of another elastic fluid, as it is in vacuo.

3. The quantity of any liquid evaporated in the open air, is directly as the force of steam from such liquid, at its temperature, all the circumstances being the same.

4. All elastic fluids expand the same quantity by heat; and this expansion is very nearly in the same equable way as that of mercury, at least from 32° to 212°. It seems probable the expansion of each particle of the same fluid, or its sphere of influence, is directly as the quantity of heat combined with it; and consequently the expansion of the fluid as the cube of the temperature, reckoned from the point of total privation.

The results of these important researches on evaporation are thus clearly summed up by Dr Balfour Stewart in his excellent treatise on heat (2d edit. p. 101), "The law of evaporation, first discovered by Dalton, may thus be stated—In a space destitute of air the vaporisation of a liquid goes on only until the vapour has attained a determinate pressure dependent on the temperature, so that in every space void of air which is saturated with vapour, determinate vapour pressure corresponds to determinate temperature."

"With reference to mixtures of gas and vapour in a confined space, Dalton's experiments lead to the following law:—'In a space filled with air the same amount of water evaporates as in a space destitute of air; and precisely the same relation subsists between the temperature and the pressure of the vapour,

whether the space contains air or not.' This law of Dalton was verified by Gay Lussac, but recently Regnault has found, by more exact experiments, that the pressure in air is always less (about 2 per cent.) than that in vacuo; he is, however, inclined to believe that Dalton's law is true in principle, and that the deviations which he noticed are to be explained by the hygroscopic character of the walls of the chamber which contained the vapour."

His essay "On the Constitution of Mixed Gases, and particularly of the Atmosphere," was not favourably received, inasmuch as his views were not so very clearly expressed, and afterwards received much modification at his own hands. The history of the controversy will be found in his "New System of Chemical Philosophy," Part i. pp. 150-193.

His second essay "On the Force of Steam or Vapour from Water, and various other Liquids, both in a Vacuum and in Air," was deemed by Dr Henry as one of transcendent importance, as first furnishing tabulated [data for the solution of perhaps the most interesting problem in meteorology; namely, the calculation, after noting the dew point, of the absolute quantity of moisture in a given volume of air. The first sentence of the essay contains the anticipation of a discovery subsequently made by Dr Michael Faraday. Dalton's words are:—"There can scarcely be a doubt entertained respecting the reducibility of all elastic fluids, of whatever kind, into liquids; and we ought not to despair of effecting it in low temperatures, and by strong pressure exerted upon the unmixed gases."

His experiments made on the vapours of sulphuric

ether, spirits of wine, water of ammonia, solution of muriate of lime, mercury and sulphuric acid, led him to entertain as a general law, "*that the variation of the force of vapour from all liquids is the same for the same variation of temperature, reckoning from vapour of any given force;* thus, assuming a force equal to 30 inches of mercury as the standard, it being the force of vapour from any liquid boiling in the open air, we find aqueous vapour loses half its force by a diminution of 30° of temperature; so does the vapour of any other liquid lose half its force by diminishing its temperature 30° below that in which it boils, and the like for any other increment or decrement of heat." Nothing could well appear more unlike in character than the six liquids operated upon by Dalton; and though the law he laid down does not universally obtain, "it is nevertheless remarkable," observes Gmelin, "that this law is pretty nearly true in the case of many substances." Dalton's views received further sanction at the hands of such great authorities as Arago, Faraday, and Dove, who have shown that although the hypothesis does not hold generally, it is approximately true for short distances on each side of the boiling point in a large number of instances.

Though Dalton experimented largely before offering his opinions "On Evaporation," it does not seem needful to do more than draw attention to the fact of its appearing with his other essays of greater import. His essay, "On the Expansion of Elastic Fluids by Heat," arising, in part, from a discussion in which several French *savans* took part, led to greater results. Dalton ascertained by repeated experiments that 1000 volumes of common air of the temperature 55°

and common pressure expand to 1325 volumes, when heated to the temperature of 212°, and he concluded that any gas at any temperature increases in volume for a rise of one degree by a constant fraction of its bulk at that temperature. He also found that hydrogen, oxygen, carbonic acid gas, and nitrous gas, expand to the same amount as common air; the minute differences observed being attributable to the presence of aqueous vapour. Gay Lussac obtained in the same year (1801) results differing but slightly from those of Dalton, the expansion for a single degree of Fahrenheit being, according to Gay Lussac, $\frac{1}{480}$ of the primitive volume at 32°, and according to Dalton $\frac{1}{483}$. Magnus and Regnault, by more exact experiments, have determined the expansion to be $\frac{1}{491}$, and their experiments leave little doubt that Gay Lussac's method of expressing the law is much nearer the truth than Dalton's.

From these experiments Dalton was led to conclude "that all elastic fluids, under the same pressure, expand equally by heat, and that for any given expansion of mercury the corresponding expansion of air is proportionally something less, the higher the temperature. . . . It seems, therefore, that general laws respecting the absolute quantity and the nature of heat are more likely to be derived from elastic fluids than from other substances. . . . As every other liquid we are acquainted with is found to expand more in the higher than in the lower temperatures, analogy is in favour of the conclusions of De Luc, that mercury does the same." It is scarcely possible, writes Dr Henry, p. 37-8, to over-estimate the value of these sagacious conclusions. They may be

affirmed to lie at the basis of the profound and hitherto unrivalled Memoir, by MM. Dulong and Petit, on the "Measure of Temperature." . . . "It is well known that their singularly precise experiments signally confirmed Dalton's sagacious inferences from his less exact researches."

Dr Henry has dwelt at some length on these four remarkable essays, because, as he says, "independently of their momentous bearing on meteorological science, they are deeply stamped with the impress of Dalton's genius, and furnish instructive types of his modes of working and thinking. His instruments of research, chiefly made by his own hands, were incapable of affording accurate results, and his manner of experimenting was loose, if not slovenly. His numerical determinations have not, therefore, like even the earlier analyses of Prout, been confirmed by subsequent inquiries. Still his experiments, though wanting the exactitude of modern research, were not unskilfully devised, and were most sagaciously interpreted. They were, perhaps, such as were most needed at the close of the last century, when so many fields of experimental research were untilled, that bold tentative incursions into new domains of thought, large groupings, and happy generalisations of approximate results were more effective instruments of advance than scrupulous precision in details. At all events, from these imperfect experiments, Dalton arrived at the discovery of those general laws of evaporation, and of the relation of air with moisture, which were translated by Biot into the exact language of analytical formulæ, and which still constitute the foundation of meteorological science."

CHAPTER VIII.

"There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy."—
SHAKESPEARE.

ELEMENTS OF ENGLISH GRAMMAR—AN EXCURSION—VARIETY OF CORRESPONDENCE—GRAMMAR AND PUPILS—THE ATMOSPHERE —FIRST INDICATIONS OF MULTIPLE PROPORTION—ELASTIC FLUIDS—ABSORPTION OF GASES—ATOMIC WEIGHTS AND INDEX TO ATOMIC THEORY.

DALTON'S educational and scientific walk was varied and laborious to a degree almost unprecedented in the pages of biography. His faithful plodding truly merited, and in due time, met with paramount success. Happily, in his struggles for a bread-and-butter existence, and his more earnest solicitation for philosophical inspiration, he possessed a hardy and robust constitution, and a northern temperament that found its most fitting stimulus in mental efforts and continuous work. How few men, even of the hardy Teutonic race, could have sustained the long and tedious hours that saw Dalton engrossed with the duties of teaching arithmetic and grammar to "young ideas!" Yet these compulsory engagements were as the play-things to his mind, whose proper pabulum was to be found in experimental research and abstruse inquiries.

As an instance of his diverging from his ordinary course of study, may be quoted the fact mentioned to his brother in a letter, dated April 14, 1794, of his reading Euler, Bernouille, and D'Alembert on "Sound;" finding, as he says, "no English author comparable to them." The business of teaching still pressed upon his other work; and in December of the same year he writes to his brother—"My time at present is much taken up with tuition at home and in the town together, so that I can scarcely turn to any particular mathematical or philosophical pursuit; but occasionally of late I have been attending to the philosophy of grammar, and to that of sound." Again, in 1801, he writes—"Since the year came in I have not been much troubled with *l'ennui.* Eight regular pupils by day, and as many more in the evenings, to whom I have sometimes given fifteen lessons a week; my Grammar in the press—the whole of it to write over and to retouch, and to attend to the press—have required a considerable activity both of body and of mind."

As his classes at the Academy in Manchester were as miscellaneous as the scholars of any school requiring indoctrination in English grammar, and as his method of teaching did not exactly coincide with the published authorities on the subject, he deemed it right to issue a work of his own. His first edition of the "Elements of English Grammar" is dated March 10, 1801, and although it is doubtful if it met with much success in point of sale,* a second edition was

* In confirmation of this view, it is said that Dalton, a few years afterwards, went into the shop of the publishers of his Grammar and asked for a copy, and was distinctly told they had none left. On his

their fancy than to sift the evidence of facts, or even to seek an explanation of the phenomena daily educible from their alembics and furnaces. Many obstacles, it is true, lay in the way of chemical research, and men who had to labour without the aid of the thermometer or the balance, and other requisites in experimental science, were unable to grasp the fruits of their industry, be it ever so sagaciously directed.

As the world grew older and better by experience and improved methods—and alchemy, with all its occult operations, should not be robbed of just credit in furnishing much that was valuable to the science —the band of investigators greatly increased in numbers, and probably in wisdom also, though not held altogether free of the imputation of *Quot homines, tot sententiæ;* so many men, so many different opinions.

Coming nearer to our own day than the mediæval schoolmen, a few instances may be adduced of men whose writings contain much of the ancient philosophy represented in briefer form and newer type, and greatly modified by modern reasonings and research—men whose intellects vied with the best of any age, and whose fame will be as lasting as European history.

Among the great men of the past whose influence still operates on the great men of the present was Descartes, the sickly child and "young philosopher" of the Jesuits; he who at the age of twenty-one years sought to divest himself of the teachings of the Conscript Fathers of the Church, and to make his mind a *tabula rasa* for the reception of a higher philosophy. It is true he made the study of mathematics and

metaphysics of more consequence than science; hence his claims to the distinction of the father of modern philosophy, and on grounds as substantial as those which elevated Lord Francis Bacon to the title of father of experimental science. In discussing physical questions he was led to discoveries in optics, &c. A few words will show his views in relation to the atomic hypothesis. He followed in part the doctrines of Plato and Pythagoras as to the divisibility of matter without any assignable limit. He banished the notion of a vacuum that so strongly possessed the Greek mind, not that nature had a horror of vacuum, but because the essence of substance being extension, wherever there is extension there is substance, consequently empty space is a chimera. He looked upon the substance filling all space as divided into equal angular parts, which, being set in motion, the parts assume a spherical form—these motions taking the form of revolving currents or vortices. On the same mode, and it was but a reaffirmation of the doctrine of the Greeks, he explained the motions of the planets.

Attention should be drawn to Spinoza, that swarthy, olive-complexioned Jew, of penetrating eye and long black hair, who suffered more for his free utterances than Jew ever did at the hands of Jews; yet this spectacle-maker was withal one of the most religious and philosophical men of the seventeenth century. Let him be, as his enemies averred, pantheist or infidel, nevertheless, his *opera posthuma* will live for ever. No doubt Spinoza was greatly influenced by Descartes' philosophy, as Goethe and others were by the persecuted Jew.

Leibnitz, the stolid German who conversed with Spinoza, looked upon the universe in its threefold relations of—1. Its elements; 2. Their manner of connection; and 3. The end of their combinations. His doctrine of elements, that they were simple unextended forces, or monads, constituted his "Monadologie." Blinded by a metaphysical, if not a theological basis, he viewed each monad as a living mirror of the universe and its physical and spiritual forces; this creation, in his eyes, involved the existence of a *monas monadum*, or One of the Supreme Infinite, from whom all that was finite was derived.

The Hon. Robert Boyle, treating of the "origin of form and qualities," records: "There is one universal matter common to all bodies, an extended, divisible, and impenetrable substance.

In the "Sceptical Chemist" he maintains that the "Aristotelian hypothesis of four elements is not comparable to the mechanic doctrine of the bulk and figure of the smallest parts of matter; for from these more universal and fruitful principles of the elementary matter may spring a great variety of textures, upon whose account a multitude of compound bodies might greatly differ from one another."

Again he says: "It seems probable that at the first production of mixed bodies, the universal matter whereof they consist was actually divided into particles of several sizes and shapes, variously moved. . . . 'Tis also possible that of these minute particles many of the smallest and contiguous ones were associated into minute masses, and by their coalitions constituted such numerous little primary concretions

as were not easily separable into the particles that compose them."

Were it desirable or consistent with this sketch of the atomic theory, the list of men who contributed opinions to the general stock of metaphysical reasoning, *quâ* the part played by atoms in the general cosmos, might be greatly extended. The views of Sir Isaac Newton may fitly close the chapter; and with the further admission, that no essential progress had been made towards the solution of the knotty question of the ultimate conditions of matter till nearly the close of the eighteenth century.

"All things considered," says Sir Isaac Newton, "it seems probable that God, in the beginning, formed matter in solid, massy, hard, impenetrable, movable particles, of such sizes, figures, and with such other properties, and in such proportion to space, as most conduced to the end for which He formed them; and that these primitive particles, being solids, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break to pieces; no ordinary power being able to divide what God himself made one in the first creation."

CHAPTER X.

THE ATOMIC THEORY FROM SIR ISAAC NEWTON TO JOHN DALTON.

"To trace in Nature's most minute design
The signature and stamp of power divine.
. . . .
The Invisible in things scarce seen revealed,
To whom an atom is an ample field."—COWPER.

THE foregoing chapter offers an outline of the efforts made by the ancients to comprehend the nature of the cosmos on the basis of atoms. The same groundwork materially influenced the speculative philosophy that long, and almost lastingly, ruled the direction of modern thought, that is seen cropping out from time to time in the hands of the Cartesians and other metaphysicians and physicists; and exercising more or less jurisdiction from the days of the poetic Lucretius down to the author of the "Principia." "The chemical atoms" may have passed across the mental vision of Geber and the polypharmists, but any recognition of their apparent nature dates no further back than the year 1777, when Wenzel in part indicated the law of reciprocal proportion; and can only be said to have attained scientific place in 1803, when Dalton propounded the essentials of his atomic theory.

To the mind of the observant reader the question will ere this have occurred, "What is an atom like?—its size, configuration, and affinities; its history, in short?" To meet such interrogations the greatest intellects of every age have devoted their energies; yet, with all their mental discernment, backed by most ingenious appliances, Nature cannot be made to disclose her arcana, much less to present herself in the nude form that would afford demonstration or conviction to the uninitiated. It may be stated *in limine*, and with a frank admission of our imperfect knowledge of the *status quo* of atoms, that inference and hypothesis guide chemists in their discussions on those infinitesimal units or particles of matter. By-and-by, however, it will be made apparent that the framing of the atomic hypothesis is not only justifiable, but found to be in accordance with both the phenomena and the facts falling within the operations of the chemist.

To give the amateur in science a notion of the minute, marvellously minute, conditions in which Nature carries on her mysterious work, a few facts may be adduced in the hope of affording him a certain amount of insight into the outer world of molecular atoms; be these atoms viewed as parts of the gaseous atmosphere, or as dense liquids, or as the more solid constituents of the organic and inorganic worlds.

The air we breathe is like a vast ocean trembling with invisible waves, of which no more tangible idea can be formed than that elicited by watching the finest dust of a sunbeam; that dust consisting of dark molecules, or aggregate masses of atoms floating amid the purer ether pervading space.

Everybody is familiar with the sting of a nettle, but few persons have examined by means of a lens the delicate hairs on the leaf of the nettle, from which the tiniest of drops escapes, the insertion of which within the human skin causes heat, redness, and irritation. But what is this irritating fluid compared with the deadly poison of prussic acid, a minim or full drop of which, in its pure, *anhydrous** state, causes death in a few seconds! Here is a strange subtlety of action that can arrest pulsation and life at once, yet all its virus is to be found in a single drop of transparent fluid! This instance of the extreme potential of force clothed in a liquid globule is rivalled in character by the revelations of the microscope displaying to us a world of *minutiæ*, of organic beauty throughout.

Turning to animal life, the microscope in the hands of Ehrenberg disclosed animalcules so infinitesimal in size that a single drop of water was computed to contain 500,000,000 of them. Here was not only a picture of a universe of atoms, but the living proof of a universe of organic beings equal in number to the entire human population on the surface of the globe!

In the fossil world geologists have traced a whole system of rocks (these calcareous masses in England

* The *anhydrous* or *pure* prussic acid is only to be seen, and that very rarely, in the hands of the scientific chemist or experimental physiologist. The medicinal prussic acid only contains about three per cent. of this anhydrous acid.

The potency of the *pure* acid, and its general toxicological and therapeutical history, constituted my graduation thesis, an abstract of which will be found in the *Edinburgh Quarterly Medical and Surgical Journal*, January 1839.

being about a thousand feet deep) composed entirely of the shells of siliceous animalcules; yet so small are these débris of a former world of organic life, that a single chalk-enamelled card of my Lady *Fashionable* form a zoological cabinet of perhaps a hundred thousand shells!

The dark spot on a soap-bubble, just before it bursts, cannot exceed $\frac{1}{4000000}$th part of an inch in thickness; yet even this is composed of many strata of atoms; for this iridescent film of moisture must consist at least of one atom of soap and one of water. Now, the atom of soap is composed of soda, stearic, margaric, and oleic acids; and the latter of, at least, one molecule of oxygen and one of hydrogen; and each of these possess the *essential* properties of impenetrability, extension, and figure.

Dr Thomson of Glasgow has shown that an atom of lead cannot exceed in weight the $\frac{1}{3100000000000}$th of a grain; and that the sulphur united with it in the form of sulphuret could not be more than $\frac{1}{2015000000000}$th of the same! Goldbeaters by hammering reduce gold to leaves so thin that 360,000 must be laid upon one another to produce the thickness of an inch; and $\frac{1}{50700000}$th of a grain may be distinguished by a common microscope. But the coating of gold on silver lace is still finer, when it is computed that the $\frac{1}{1400000000}$th of a grain, spread out as a distinct layer of gold, may be seen through a good lens.

The contemplation of these remarkable proofs of the molecular forms and *minutiæ* pervading Nature's great plan, may help the reader's belief to a more infinitesimal condition of matter than has been set

forth, or is ever likely to be demonstrated; and at the same time tend to promote his sanction of doctrines that chemists have found it needful to frame upon a theoretical consideration of the atomic constituents of bodies.

Not only is our planet, in all its granitic framework, and its liquid and aerial construction, built up of indescribably minute particles, or the atoms of the sixty-three elementary substances noted by chemists; but, relying on the observations made by the spectrum analysis, which finds the vapours and the metals of earth in the radiant streaming aurora borealis, and in the central nucleus of comets, it is fair to infer that such also is the construction of the great orbs in the firmament. Such phenomena are of striking interest, as illustrating the structural inorganic analogies pervading the universe, upon which the natural theologian may found an attractive teleological theme, not so striking or convincing in character, perhaps, as one that might be drawn from the contemplation of the organic morphological types so strikingly visible and intelligible to all men of culture and education.

The atom in the physical world is like the cell in the biological world—that morphological unit or ultimate element of form out of which all the organs in the living body are built up. As every organised being derives its existence from a sphere of protoplasm and cell-growth, so does every chemical change rest on the fresh arrangement of molecular atoms. The microscope enables the anatomist to define the organic cell in some of its phases; but no one has been able to see or handle a single molecule. Mole-

cular science, therefore, is apt to create a doubt in the minds of many, inasmuch as it is a branch of study which treats of things invisible, and imperceptible by our senses, and necessarily beyond direct experiment and proof.

Any attempt to evolve the beginning or the ending vibration of the ultimate atoms of matter would only bewilder the imagination, and reduce the mightiest of intellects to the submissive attitude of acknowledging the infancy of man's knowledge, and the finiteness of his reach compared with the transcendent depth of Nature's operations, as displayed in the countless Infinite.

How are we to arrive at a clear notion regarding the size of an atom, when its minuteness escapes the detection of the most powerful microscope yet made, or likely to be constructed? Ehrenberg's researches, some of which have been already mentioned, led him to infer that the diameter of an atom (the molecule of the chemist) was considerably less than six-millionths of a line. Quite recently, Sir W. Thomson, in a paper "On the Size of Atoms," presented four lines of argument founded on experiments of physicists, which all lead to substantially the same estimate of the dimensions of molecular structure. He says:—

"Jointly they establish, with what we cannot but regard as a very high degree of probability, the conclusion that, in any ordinary liquid, transparent solid, or seemingly opaque solid, the mean distance between the centres of contiguous molecules is less than the hundred-millionth, and greater than the two thousand-millionth of a centimetre. To form some conception of the degree of cross-grainedness indicated by this conclusion,

imagine a raindrop, or a globe of glass as large as a pea, to be magnified up to the size of the earth, each constituent molecule being magnified in the same proportion. The magnified structure would be coarser grained than a heap of small shot, but probably less coarse grained than a heap of cricket-balls.

. . . .

"Beyond this point of extreme tenuity, where matter first exhibits that property which is revealed in visible forms, we are forced to consider it in a still more expanded state, as the universally diffused medium of light, heat, and actinism."

Here it may be observed that science informs us of two modes in which elementary bodies combine, the chemical and the mechanical; the chemical being generally viewed as a true and vital fusion between atoms, whilst the mechanical is only a simple bond of juxtaposition. My last chapter concluded with a quotation from Sir Isaac Newton, cautiously expressing a theory on the nature of atoms that rested on mechanical grounds.

Among others of the last century who broke ground in the direction of a truer science than reigned in the preceding one (the seventeenth), and who deserve honourable mention, were Boscovich, Cullen, Black, Bergman, the Wenzels, Richter, and the two Higgins.

The Abbé Boscovich, in his work on Natural Philosophy, in 1759, gave the fullest expression to the *dynamical* theory of matter. According to Dr Daubeny ("Atomic Theory," p. 34)—

"Boscovich supposes that matter is made up of a number of unextended indivisible points, which, however, never touch each other, owing to the mutual repulsion subsisting between them, as soon as they come within a certain distance of each other; which repulsion, increasing gradually in proportion as they are made to approach nearer and nearer, becomes at length too powerful for any force to overcome.

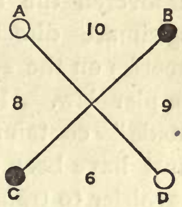
"Dealing with particles as with matter formed of indestructible atoms, 'he supposes that the points of matter alternately attract and repel each other, according to the distance that separates them, until they either come very close to, or are removed to a comparatively great distance from each other; in the former case they are repelled, in the latter attracted; the former force preventing mutual contact, the latter, which, when considered as acting between the earth and bodies upon it, is no other than gravitation, drawing them all together.'"

Dr William Cullen, who raised himself from the humblest position in Scottish life to the rank of the most distinguished physician of his epoch, applied his methodical mind to the elucidation of the higher science pertaining to the physical elements, and stepped far beyond the usual limits assigned to a professor of chemistry and medicine.

Dr Angus Smith had the good fortune to find a manuscript copy of the lectures delivered by Dr Cullen in 1762-63, from which the following facts are gathered. Cullen, reasoning from the prevalent doctrines, was of opinion that no physical element or chemical principle possessed fixed and permanent qualities. He afterwards adds: "Having laid down and demonstrated this fundamental proposition—viz., that the changes of the qualities of bodies are all of them produced by combination or separation—I now proceed to inform you that combination depends upon *attraction*, that is, the attraction of cohesion, whereby the small particles of bodies very near each other are disposed to approach, and in a certain contiguity to remain coherent together." He also explained "simple elective attraction and double elective attraction by diagrams," and anticipated by

some years the views somewhat similarly expressed and illustrated by Bergman.

Dr Black, whose name is associated with the doctrine of latent heat, succeeded Dr Cullen, and also imbibed his views. Thus he "taught that bodies combine in definite proportions, and explained double decomposition by means of diagrams, not, indeed, the same as those of Mr Higgins" (to whom allusion will presently be made), but much simpler and more elegant. "I have no doubt," continues Dr Smith, "that all similar diagrams published in London by Dr Fordyce, &c., were derived from the same source. Now, could the doctrine of definite proportions be taught, and could double decomposition be explained in this way (I quote Dr Black's explanation), let the bodies A and B be united with a force, 10; and the bodies C and D with a force, 6. Suppose the attraction of A for C to be 8, and that of B for D to be 9, if we mix these bodies, A will unite with C, and B with D. To me they conveyed just as much of the atomic theory as the perusal of Mr Higgins' book did" (p. 146).



Those who wish for ampler explanation of Dr Cullen's views, will find them in a letter of his to his pupil, Dr George Fordyce of London, in Oct. 1759; which my old teacher, Professor John Thompson, quotes in his Life of Cullen. Both the text and diagrams justify Dr Smith's opinion, that Dr Cullen was the first who used the words and explanations

in the manner afterwards made so famous by Bergman. And Dr Smith has done Bergman full justice, and attributes to him "a valuable discovery in the establishment of the permanence of the amount of oxygen in precipitated oxides, the very foundation of analysis, and an important step towards the knowledge of permanence of constitution in all substances whatever."

Richard Kirwan the Irishman, Copley Medallist of the Royal Society of London, and afterwards President of the Royal Irish Academy, experimented very much in the direction which Bergman had followed. He is another of those who nearly discovered the atomic theory, who laboured in a legitimate direction, but whose discoveries and theories on the subject are merged in a higher and simpler law. His "Essay on the Constitution of Acids" contains much original observation, and must have been of some interest to induce the great Lavoisier to translate it into French, and afterwards to criticise its doctrines.

Among the claimants to the discovery of the earliest stages in the atomic theory, Wenzel has had high place. Thus, according to Dr Henry—

"Wenzel ascertained, by a numerous series of analyses far surpassing in accuracy those of any other chemist of his time, that the different weights of the alkalies or earths which neutralise the same weights of any given acid, also require for their neutralisation an equal quantity of every other acid; in other words, that the relative proportions between certain quantities of alkalies or earths, which saturate a given weight of one and the same acid, remain the same with all other acids; hence the persistence of the state of neutrality after double decomposition, whether the two salts are mingled in the exact

proportions necessary to entire decomposition or not. Wenzel had the rare merit of discovering all the consequences flowing from this prolific truth; he perceived that the composition of neutral salts being thus subordinate to definite laws, it is possible by the careful analysis of a few to ascertain the constitution of many others by a simple calculation. He did not, however, pursue this important line of research, his main object having been to explain the persistence of neutrality after mutual decomposition."

Another version, and probably a more correct one, of Wenzel's work, will be found in Dr A. Smith's biography of Dalton, derived at least from a careful examination of Wenzel's rare volume, "The Doctrine of the Affinity of Bodies," published in 1777. Dr Smith shows that the reciprocal saturation which results when two salts decompose each other, is due to Wenzel; and whilst admitting this great service in seeking for the distinct constitution of bodies, and the constancy of combination, will not concede to him the claim of having established the doctrine of *reciprocal proportion*, with which his name has hitherto been associated.

Dr Bryan Higgins of London was a man of parts, and, judging from a pamphlet proposing a course of lectures, in Nov. 1775, for "literary noblemen," not disposed to hide his talents under a bushel. He believed in the existence of seven primary distinct elements of matter—earth, water, air, alkali, acid, phlogiston, and light; that each element consists of atoms homogeneal, impenetrable, immutable in figure, inconvertible, and in the course of nature neither annihilated nor newly created. Dr Angus Smith finds nothing in Dr Higgins' writings to indicate that he had formed any correct idea of definite compounds. "Dr

Higgins thinks of atoms, of simple particles, and even speaks of gases uniting, in some cases, in nearly, if not accurately, a fixed proportion, and yet he sees no law. He does not carry his idea far enough. . . . As far as our subject is concerned, Dr Higgins has small claims. His opinions on atoms might have been held by the ancients, whilst, standing on their shoulders, it would have required much less sagacity to discover than was needed for them. He speaks of the sums and the forces of atoms measuring the attraction of matter, but does not suppose that if matter be atomic, the number of atoms might also in this way be got comparatively" (p. 175).

Another member of the family of Higgins, one who received his first instructions in chemistry from his relative Dr Bryan, was William Higgins of Pembroke College, Oxford, who issued a volume in 1789, entitled "A Comparative View of the Phlogistic and Antiphlogistic Theories, with Inductions." It is needful to offer some quotations from the work of the Oxonian, as larger credit has been given to him than to any other writer whose views have been held anticipatory of Dalton's promulgation of the laws of combination. As phlogiston still held sway with chemists, and formed part of their nomenclature, it will be well to translate, as Dr Henry has done, the terms used by Mr Higgins into the language of modern chemistry.

Mr Higgins, referring to the combinations of sulphur and oxygen, thus expresses himself:—

"100 grains of sulphur, making an allowance for water, require 100 or 102 of the real gravitating matter of oxygen to form sulphurous acid gas, and as this gas is little short of double the

specific gravity of oxygen, we may conclude that the ultimate particles of sulphur and oxygen contain equal quantities of solid matter, for oxygen suffers no considerable contraction by uniting to sulphur in the proportion merely necessary for the formation of sulphurous acid. Hence, we may conclude that in sulphurous acid a single ultimate particle of sulphur is intimately united only to a single particle of oxygen, and that, in sulphuric acid, every single particle of sulphur is united with two of oxygen, being the quantity necessary to saturation." Still more in conformity with modern doctrine is his view of the composition of water :—"As two cubic inches of hydrogen require but one of oxygen to condense them, we must suppose that they contain an equal number of divisions (atoms), and that the difference of their specific gravity depends chiefly on the size of their ultimate particles; or we must suppose that the ultimate particles of hydrogen require two or three, or more, of oxygen to saturate them. If this latter were the case, we might produce water in an intermediate state, as well as sulphuric or nitrous acids, which appears to be impossible; for in whatever proportion we mix our airs, or under whatsoever circumstances we combine them, the result is invariably the same. This likewise may be observed with respect to the decomposition of water. Hence, we may justly conclude that water is composed of molecules, formed by the union of a single particle of oxygen to an ultimate particle of hydrogen, and that they are incapable of uniting to a third particle of either of their constituent principles" (pp. 37 and 38). Equally meritorious was his sagacious anticipation of the composition of the nitrous compounds :—"I am of opinion that in nitrous gas every primary particle of azote is united to two of oxygen, and that these molecules are surrounded by one common atmosphere of fire." He has given a diagram exhibiting the mode in which he supposed the nitrous oxide gas, then recently discovered by Dr Priestley, to be formed, so as to consist of one particle of azote and one of oxygen, the constitution now assigned to it. His views regarding the composition of this other compound of azote and oxygen were purely conjectural.

"The impartial historian," writes Dr Henry, "will certainly not withhold from the author of these in-

genious views, the praise of uncommon sagacity; though, after a careful perusal of the entire work, he will pronounce them to be rather brilliant conceptions, hastily struck off, than the fruits of sober and sustained induction. It is evident that Mr Higgins was guided by no fixed and uniform principle in assigning the atomic constitution of the above compound bodies."

The title of Mr Higgins' volume was not encouraging, inasmuch as it pertained to phlogiston, a kind of *materies morbi* that had long tended to retard the progress of chemistry, and though then in its last throes—thanks to Lavoisier—gave a smack of empiricism to the science that men of original conception gladly sought to avoid. Hence, it is not a matter of surprise that the work was less known than it should have been. More than this, however: many of Mr Higgins' opinions bearing on this narrative were hidden from view by his larger controversial statements and inconsistencies; and the probability is that the book, though placed in the hands of so distinguished a chemist as Professor Thomson of Glasgow, would have passed into oblivion had not Dalton's memoirs attracted European attention, and caused Mr Higgins to step forth and claim the discoveries of the Manchester schoolmaster for himself. In 1814 Mr Higgins issued his "Experiments and Observations on the Atomic Theory," for the purpose of vindicating his title to be regarded as its discoverer, and by implication charged Dalton with plagiarism.

In defence of Dalton's fair fame, it is imperative to show how this false imputation of Mr Higgins' was

met by Dalton's friends, and especially those who were in almost daily intercourse with him, as well as others living at a distance from Manchester, to whom he had at all times been frank and communicative on scientific subjects. Dr Henry, the able biographer of Dalton, writes:—"I have heard my father affirm, on various occasions, and to various persons, that Dalton had never seen Mr Higgins' work till some years subsequent to the publication of the 'New System,' when it was lent to him by my father. And further, it appears from a memorandum of Dr Henry, senior, that Professor John Leslie, on a visit to Manchester, told Dalton that Sir H. Davy, in a paper in the 'Philosophical Transactions,' had denied his (Dalton's) claim to the atomic theory, and had set up one for Higgins." This took Dalton by surprise, as he had neither seen Higgins' book nor Davy's memoir. The "Philosophical Transactions" had not reached either of the two Fellows of the Royal Society residing at Manchester (Dalton was not then a Fellow); and as already stated, he was obliged to his friend Dr Henry, senior, for a perusal for the first time of Higgins' work.

Dr Henry's evidence seems conclusive, and it derives large confirmation from the fact that Dalton, at no period of his life, devoted much time to reading. Those who have attentively read the earlier chapters of this memoir will have gathered that he was intuitively so reliant on his own observations and ideas, and so wedded to his own interpretation of nature, that he omitted to make himself acquainted with the history of the subject engaging his attention. What Playfair said of Dr Hutton is thoroughly applicable

to Dalton: "that the originality of his own conceptions, and the little regard he had to authority in matters of theory, relieve us from the necessity of looking to others for the sources of his opinions."

As regards the effect that Higgins' book had on his contemporaries, Dr Thomson of Glasgow is the best authority. Now Dr Thomson, in his "Annals of Philosophy" (May 1814), vol. iii., p. 331, says—"I have certainly affirmed that the atomic theory was not established in Mr Higgins' book. And here is my reason. I have had that book in my possession since the year 1798, and have perused it carefully; yet I did not find anything in it which had suggested to me the atomic theory. That a small hint would have been sufficient, I think pretty clear from this, that I was forcibly struck with Mr Dalton's statements in 1804, though it did not fill half an octavo page; so much so, indeed, that I afterwards published an account of it, and I still consider myself as the first person who gave the world an outline of the Daltonian theory."

Dr R. Angus Smith's criticism on the respective merits of Mr William Higgins and his predecessor, Dr Bryan Higgins, appears so judicious that I cannot do better than quote it. He writes:—

"William Higgins made an advance on Bryan Higgins in this theory of sulphur and heat, and he was a man evidently of an acute mind. But he was destined to find Emerson's saying true, that we often find in the sayings of great men our own rejected ideas. He was heir to the common opinion that atoms existed, and the opinion of Dr Higgins that they united and formed molecules of compound bodies. He applied the reasoning further, and said that they must then unite in numbers of one or two or three, and that there could be no intermediate com-

bination, as there were no intermediate division of atoms. He applied this reason in two or three cases. These cases, such as nitric acid, are so clear and beautiful, that we can only be surprised that the general law was not seized on. They are the first clear and satisfactory reasons given for saturation, and for definite proportion in general. Higgins was therefore the first man who used the idea of atoms with such force as to be serviceable in chemistry. He used the idea of ultimate particles and the molecular state of bodies to illustrate saturation, and definite and multiple proportion, and gave us, therefore, the fundamental ideas of stoechiometry as they existed in chemical science, from which everything else might have easily flowed" (p. 183).

Again—"I look upon Higgins as the first man who ever in his imagination formed a correct atomic compound, and gave a correct analysis, in spite of his thousands of previous speculations and the simplicity of the idea, but one who lost the opportunity of elevating his idea into a great law of nature. It is well to express the claim of a discoverer in the widest and in the fewest words. He expressed the fact of atomic simple and multiple proportion, which is the foundation for all the other atomic laws, although in his mind it was not raised to the dignity of a great law, and it is for great laws only that we can give great honours in this case.

"Higgins speaks so clearly and simply that we can readily believe that he would have illustrated the laws of chemical combination with great beauty had he seen the great value of his ideas. There is no obscurity in his language—there is no difficulty in telling exactly his place in science; but there is a difficulty in defining it exactly when we have to deal with Dalton, who grasped the whole so much more firmly, enlarged it, placed it, and established it in a series of laws" (pp. 184–5).

No one, as far as my reading extends, ever made an important discovery in science without the accompaniment of an unwelcome challenge being offered to his claims to priority by his contemporaries. Dalton had taken too great strides in the path of original research, and achieved too much to escape

the common fate of mortals possessing genius and foresight in advance of their epoch. It was said that his atomic views were not new; that he had been anticipated by Democritus the Greek, and in his own century by Wenzel, Higgins, and Richter. After showing the fallacy of the claims of the two first-named with his usual painstaking industry and fairness, Dr R. A. Smith goes fully into Richter's views, quoting largely from his works,* and with due consideration to the merits of this renowned German.

In his preface, Richter says:—"As the mathematical portion of chemistry deals in a great measure with bodies which are either elements or substances incapable of being decomposed, and as it teaches also their relative magnitudes, I have been able to find no more fitting name for this scientific discipline than the word stoechiometry, from *στοιχειον*, which, in the Greek language, means a something which cannot be divided, and *μετρειν*, which means to find out relative magnitudes." Here, then, was an effort worthy of Richter to make the study of atomic chemistry a science. He also indicated that the smallest portions of a body are of the same composition as the largest, that the affinity exists in every particle—an illustration, Dr Smith remarks, afterwards used by Dalton on the same subject, but in clearer words, and still earlier by Higgins. This idea leads directly to the atomic theory, and theory of equivalents; but it was not followed out by Richter. Again writes Dr Smith:—"The

* Richter's books are—"Anfangsgründe der Stoechyometrie oder Mess-Kunst. Chymischer Elemente," 3 vols. Breslau und Hirschberg, 1792–94; and "Ueber die Neuern Gegenstände der Chymie," 1792–1802.

discovery of reciprocal proportions is given by no one before Richter, as far as I know; but he himself does not speak of it as a discovery, but as a well-known fact, with which he was familiar before he wrote his inaugural dissertation." The following is worthy of quotation from the same pen :—

"It certainly is difficult to tell how discoveries grow, often impossible to tell who is the discoverer; but this we may consider a fair rule, not always easily applied, it is to be confessed, that he is a discoverer who sees distinctly the full bearing of his discoveries; when this does not happen, there is a difficulty in giving that man the place due to him. It is clear that Richter, like some others already mentioned, had fundamental principles which would have led him to the atomic theory; but he has evidently been led by foregone conclusions, and the law of planetary distances has been floating in his mind and misleading him when seeking for the differences in the combining weights of bodies.

"The discovery of reciprocating proportion was a very important and memorable one, although the scientific world did not recognise it. . . . Who discovered this very important fact, it is still left unascertained: as the expression of a law, it is Richter's; but as a fact regarding neutral salts, the author appears not to be known.

"As a general summary of Richter's most important works, we may say he found that there was a certain quantitative relation between all bodies; and he made out the laws so far, that when he knew the quantitative analysis of a salt, he could tell its quantitative decomposition with another. But he never saw it with sufficient clearness to be able to express the combining quantities each by its own distinct number; nor does he appear to have ever proceeded far enough to be able to assign a cause for the phenomenon, or to connect it with any fundamental idea.

"It has been said that Dalton had read Richter, and had never acknowledged his claims. It is a melancholy thing to see men of talent and learning so readily distrusting their own class, as

if dishonesty were so common. I might say the same of Richter, that for more than ten years he continued to publish on stoechiometry, and never once mentioned Higgins; but his whole works show that he did not see Higgins' writings, or he would have probably got less involved than he did. We learn from Dr Henry that Dalton had seen Richter's results on reciprocal proportions, and had received assistance from them; but although they may have assisted him in proving his laws, Richter could never have given him fundamental ideas. These are much wanted in Richter's chemistry. Richter's cotemporaries did not obtain the atomic theory, although some were students of his work. Berzelius himself did not obtain the atomic theory from Richter, although the most illustrious of the students of Richter's books. Dalton, then, could not have obtained it, and the direction he takes is perfectly different, the road he went quite clear, and the results he came to entirely distinct from that aimed at by Richter."

Other authors, notably Fischer, Berthollet and Proust, took a part in the same direction as Higgins and Richter; but it would profit nothing to offer an analysis of their work, nor to enter upon the antagonistic relations of the two last-named chemists. Having afforded the reader an opportunity of judging of the labours of his predecessors, it is now imperative to set before him Dalton's own investigations, upon which are based the modern doctrine of the atomic theory.

CHAPTER XI.

JOHN DALTON ESTABLISHES THE ATOMIC THEORY.

"*Philosophy is the art of deciphering the mysteries of nature; and every theory which can explain the phenomena has the same evidence in its favour that it is possible the key of a cypher can have from its explaining that cypher.*"—HARTLEY.

LET the historian, faithful to his trust, render all honour to such illustrious men, as Cullen, Black, Bergman, Wenzel, the kinsmen Higgins, Richter, and Proust, for excavating the foundations, and holding the plumb-line in the erection of an edifice that was to become, in the hands of John Dalton, a noble structure of magnificent proportions. These men were no common masons, but skilled designers, each of whom brought fitting patterns, and true carving power, to the architectural lines of the Temple of Chemistry, the adornment of which was so happily realised by the Grand Master—Dalton.

In obtaining access through the outer approaches of all discoveries in art, science, or philosophy, there must necessarily be sappers and miners, the pioneers in the undertaking; and though several laboured right soldierly at the fortifications, William Higgins made the boldest effort to carry the citadel that contained the treasures of a new and fundamental doctrine in the physics of chemistry. That he did not entirely succeed was very much owing to his judgment being

warped by phlogistic theories. It should be observed that whilst Cullen and Black stood in the relation of master and pupil and constant friends, the other, and equally renowned, coadjutors in the preliminary construction of the atomic theory acted independently of each other, and lived far apart, so that their labours were comparatively little known to each other, or to the world at large. Had the same freedom of intercourse existed a hundred years ago between nations and their representatives that now prevails, Dalton's discovery in 1803, admittedly based on his own unaided researches, would probably have been anticipated by ten or more years. Thus had the leading ideas in Mr Higgins' mind, pointing to the law of definite composition and multiple proportion, come to the knowledge of Lavoisier, the whole fabric of the atomic theory would have sprung forth as a happy generalisation worthy of this noble cultivator of the science.

After recalling the import of the various essays emanating from Dalton's fertile mind during his first decennial period in Manchester—his clear conception of the nature of mixed elastic fluids, his eudiometrical observations, his inquiry into the tendency of elastic fluids to mutual diffusion, and his researches on the absorption of gases by water, through all of which may be traced an obvious and natural affiliation of thought—Dr Henry observes:—"To the same parentage we may now trace his first vision of the atomic constitution of matter. It is impossible to peruse the essay on the constitution of mixed gases, and especially to contemplate the plate of atomic symbols used by Dalton as late as 1835, by which it is illustrated (see appendix for plate), without perceiving that medita-

tion on the constitution of homogeneous and mixed elastic fluids had impressed his mind with a distinct picture of self-repellent particles or atoms. Thus, he affirms, homogeneous elastic fluids are constituted of *particles* that repel one another with a force decreasing directly as the distance of their centres from each other. Again: it follows, too, that the distances of the centres of the *particles*, or, which is the same thing, the diameters of the spheres of influence of each *particle*, are inversely as the cube-root of the density of the fluid." But the plate which is reproduced in the appendix furnishes ocular demonstration that it was in contemplating the essential condition of elastic fluidity that he first distinctly pictured to himself the existence of atoms. As, however, the origin of this great conception is doubtless the most interesting circumstance in his life, I copy verbatim the following minute in my father's handwriting, dated 1830, February 13, of a conversation with Mr Dalton:—"Mr Dalton has been settled in Manchester thirty-six years. His volume on meteorology, printed, but not published, before he came here. At p. 132 *et seq.* of that volume, gives distinct anticipations of his views of the separate existence of aqueous vapour from atmospheric air. At that time the theory of chemical solution was almost universally received. *These views were the first germs of his atomic theory, because he was necessarily led to consider the gases as constituted of independent atoms.* Confirmed the account he before gave me of the origin of his speculations leading to the doctrine of simple multiples, and of the influence of Richter's table in exciting these views. Thus far, then, we can trace a natural

filiation of thought, in unbroken sequence, from—(1.) The vigilant and persistent observation of meteorological phenomena, and specially of the variations *of the atmosphere* in weight, temperature, and *moisture;* to (2.) The theory of the relations of air and vapour, and of mixed gases; and finally, to the abstract conception of elastic fluidity, and of self-repulsive molecules or atoms. There remained, however, a wide space to be traversed, from this general physical conception of the existence of atoms to the experimental establishment of *the relative weights* of the ultimate particles of various chemical elements and compounds, announced by him two years afterwards—October 1803.

Reference to a previous page (158) will show that Dalton, in one of his earliest chemical memoirs in 1802, had discovered, in the combinations of oxygen with nitrous gas, an undoubted example of multiple proportions; or to use his own words:—"These facts clearly point out the theory of the process; the elements of oxygen may combine with a certain portion of nitrous gas, or with twice that portion, but with no intermediate quantity." The steps by which he ascended from this first special example to the general law of multiple proportion seems pretty clearly indicated as resulting from the observations he made on the light carburetted hydrogen and olefiant gas. Dr Thomson of Glasgow, who spent a day or two with Dalton in Manchester, in August 1804, offers a clear narrative of the origin of the atomic theory in the following words:—"Mr Dalton informed me that the atomic theory first occurred to him during his investigations of olefiant gas and carburetted hydrogen

gas, at that time imperfectly understood, and the constitution of which was first fully developed by Mr Dalton himself. It was obvious, from the experiments which he made upon them, that the constituents of both were carbon and hydrogen, and nothing else; he found, further, that if we reckon the carbon in each the same, then carburetted hydrogen contains exactly twice as much hydrogen as olefiant gas does. This determined him to state the ratios of these constituents in numbers, and to consider the olefiant gas a compound of one atom of carbon and one atom of hydrogen; and carburetted hydrogen of one atom of carbon and two atoms of hydrogen. The idea thus conceived was applied to carbonic oxide, water, ammonia, &c., and numbers representing the atomic weights of oxygen, azote, &c., deduced from the best analytical experiments which chemistry then possessed" ("History of Chemistry," vol. ii., p. 291).

In treating of carburetted hydrogen long afterwards, in 1810 ("New System," vol. i., p. 444), Dalton writes:—"No correct notion of the constitution of the gas about to be described seems to have been formed till the atomic theory was introduced and applied in the investigation. It was in the summer of 1804 that I collected, at various times and in various places, the inflammable gas obtained from ponds." He had therefore been working at the analysis of this gas just previously to Dr Thomson's visit. Moreover, in his first table of atomic weights (see page 158), in which hydrogen being unity, carbon was estimated 4·3, olefiant gas is represented by 5·3—that is, C+H, and carburetted hydrogen from stagnant water by 6·3, or C+2H. This same table supplies other examples

of the law of multiple proportions, which (in the absence of more direct testimony) we may reasonably presume to have constituted the foundations of that most significant generalisation. Thus carbonic oxide and carbonic acid are denoted by numbers equal to $C+O$ and $C+2O$ respectively; sulphurous and sulphuric acid by numbers equal to $S+O$ and $S+2O$; and three of the nitrous compounds—nitrous oxide, nitrous gas, and nitric acid—by numbers equivalent to $2N+O$, $N+O$, and $N+2O$.

His correspondence with his brother offers substantial confirmation as to the date of his original work. Thus, on March 21, 1803, he informs his brother:—"I have been, as usual, fully engaged in all my leisure hours in the pursuit of chemical and philosophical inquiries. Even my Christmas vacation was taken up in this way; indeed, I have had considerable success of late in this line, having got into a *track that has not been much trod in before.*" This is conclusive that he had in the autumn or early winter of 1802 struck upon a new path of such absorbing interest that he would not allow the Christmas holidays to interfere with its fuller development.

On reviewing the early stages of his scientific life, with the view of tracing the genesis of the atomic theory, you cannot but revert to Dalton's methodical labours to interpret the constitution of the atmosphere, a subject upon which he dwelt with the fondness of a parent proud of his offspring. Thus, in his preface to the second edition of his "Meteorological Essays," issued in 1834, or forty-one years after the first, he says:—"I have been the more anxious to preserve the first edition unchanged, as I apprehend it contains

the forms of most of the ideas which I have since expounded more at large in different essays, and which have been considered discourses of some importance."

In Chapter II. of his "New System," treating on the constitutions of bodies, and especially on pure and united elastic fluids, he says, *inter alia*, that "all bodies are constituted of a vast number of extremely small particles or atoms of matter, bound together by a force of attraction. . . . Besides this, we find a force of repulsion. This is now generally, and I think properly, ascribed to the agency of heat. An atmosphere of this subtle fluid constantly surrounds the atoms of all bodies, and prevents them from being drawn into actual contact." Again—"In prosecuting my inquiries into the nature of elastic fluids, I soon perceived it was necessary, if possible, to ascertain whether the atoms or ultimate particles of the different gases are of the same size or volume in like circumstances of temperature and pressure."

His inquiries into the density of the gases afforded to his mind clear evidence in support of the existence of ultimate indivisible particles, and led him, unconsciously perhaps, to the revival of the atomism propounded by Democritus and others, that now and then cropped out in history, with, however, little or no scientific significance, and when resuscitated by Descartes and Newton, not treated as applicable to the laws of chemistry.

"From a careful examination of all the evidence before me," says Dr Henry, "I am led to conclude that the facts and reasonings on which the first table of atomic weights was based, were assembled by

Dalton during the years 1802,* 1803, and 1804, and that the discovery of the law of multiple proportions was, in the order of mental operations, the immediate antecedent of the atomic theory of chemical combination. Thus it will be seen, on inspection of the table given in page 158, that of the fifteen compound atoms whose weights are assigned, not fewer than nine are examples of multiple proportions—viz., the two carburetted hydrogens, the two compounds of carbon and oxygen, the two compounds of sulphur and oxygen, and the three of oxygen and nitrogen. It is also worthy of remark, as confirming the genealogy of the atomic theory, already traced from the abstract conception of elastic fluidity, that of the twenty-one bodies comprehended in Dalton's earliest table, sixteen are either permanent gases or vaporisable bodies; and that of the remaining five, Dalton calculated the atomic weights of the three solids, carbon, sulphur, and phosphorus, from the analysis of their *aëriform* combinations with hydrogen and oxygen, and those of the two liquids, sulphuric and nitric acids, from the lower *aëriform* compounds of sulphur and azote respectively with oxygen. Not a single metal, alkali, or earth, appears in this first table. The atomic weights of these *solid* bodies were first published by him in the description of Plate IV. of his "New System," Part I., p. 219, 1808.

It seems pretty clearly established that the

* The earliest examples of his atomic weights were probably obtained before November 1802. In the preface to the first part of his "New System," Dalton writes :—"In 1803 the author was gradually led to those primary laws which seem to obtain in regard to heat and to *chemical combinations*, and which it is the object of the present work to exhibit and elucidate."

hypothesis of the atomic theory arose in Dalton's mind from the study of matter in an *aeriform* condition; that its first practical application in chemistry was to *gaseous* bodies, and particularly to such as combine in *multiple proportions.* How far Dalton was influenced by the law of *reciprocal proportions* or equivalents of Richter may admit of question; but looking to the evidence adduced by Dr Henry, senior, as well as his son (Dalton's biographer), there is reason to think that some of the earlier speculations which gave birth to the atomic theory were in part suggested by the experiments of Richter on the neutral salts. The German chemist, having ascertained the quantity of any base—as potass, for example—which was required to saturate a hundred measures of sulphuric acid, then set to work to determine the quantities of the different acids which were adequate to the saturation of the same quantity of potass. In this fashion a table was formed exhibiting the proportions of the acids and the alkaline bases constituting neutral salts. "It immediately struck Mr Dalton," writes Dr Henry, "that if those saline compounds were constituted of an atom of acid and one of alkali, the tabular numbers would express the relative weights of the ultimate atoms." Dr Henry continues:—"My own belief is, that during the three years (1802–4) in which the main foundations of the atomic theory were laid, Dalton had patiently and maturely reflected on all the phenomena of chemical combination known to him, from his own researches and those of others, and had grasped in his comprehensive survey, as significant to him of a deeper meaning than to his predecessors, their empirical laws of constant and reciprocal

proportion, no less than his own law of multiple proportion, and his own researches in the chemistry of aeriform bodies."

A few quotations from Dalton's chapter on "Chemical Synthesis" will be serviceable in illustrating his theory.

"ON CHEMICAL SYNTHESIS.

"When any body exists in the elastic state, its ultimate particles are separated from each other to a much greater distance than in any other state; each particle occupies the centre of a comparatively large sphere, and supports its dignity by keeping all the rest, which by their gravity, or otherwise, are disposed to encroach upon it, at a respectful distance. When we attempt to conceive the *number* of particles in an atmosphere, it is somewhat like attempting to conceive the number of stars in the universe; we are confounded with the thought. But if we limit the subject, by taking a given volume of any gas, we seem persuaded that, let the divisions be ever so minute, the number of particles must be finite; just as in a given space of the universe, the number of stars and planets cannot be infinite.

"Chemical analysis and synthesis go no further than to the separation of particles one from another, and to their reunion. No new creation or destruction of matter is within the reach of chemical agency. We might as well attempt to introduce a new planet into the solar system, or to annihilate one already in existence, as to create or destroy a particle of hydrogen. All the changes we can produce consist in separating particles that are in a state of cohesion or combination, and joining those that were previously at a distance.

"In all chemical investigations it has justly been considered an important object to ascertain the relative *weights* of the simples which constitute a compound. But unfortunately the inquiry has terminated here; whereas from the relative weights in the mass, the relative weights of the ultimate particles or atoms of the bodies might have been inferred, from which their

number and weight in various other compounds would appear, in order to assist and to guide future investigations, and to correct their results.

"Now, it is one great object of this work to show the importance and advantage of ascertaining *the relative weight of the ultimate particles, both of simple and compound bodies, the number of simple elementary particles which constitute one compound particle, and the number of less compound particles which enter into the formation of one more compound particle.*

"If there are two bodies, A and B, which are disposed to combine, the following is the order in which the combinations may take place, beginning with the most simple, namely:—

1 atom of A + 1 atom of B = 1 atom of C binary.
1 atom of A + 2 atoms of B = 1 atom of D ternary.
2 atoms of A + 1 atom of B = 1 atom of E ternary.
1 atom of A + 3 atoms of B = 1 atom of F quaternary.
3 atoms of A + 1 atom of B = 1 atom of G quaternary, &c., &c."

This was followed by rules of guidance respecting chemical synthesis, and the introduction of plates exhibiting the modes of combination. The elements or atoms of bodies viewed as simple were denoted by a small circle with some distinctive mark, and their combinations were also represented in a way to be understood. He also furnished a plate of the "arbitrary marks or signs chosen to represent the several chemical elements or ultimate particles."

His atomic weights were inexact, but this was to be expected in the infancy of the science. He seemed to be aware of this, and expressed great caution, both as to the accuracy of his numbers and his weights, and not less our viewing substances as simple in their nature, which a higher analysis might prove to be compound.

Here it is needful to consider the laws of propor-

tional combination which are everywhere accepted as true by chemists. These laws are generally viewed as three in number, but Dr George Wilson held out for a fourth: all the laws refer to combination by *weight*. Three of these, as Wilson affirms, were discovered by Dalton, and all of them were brought into new prominence by his labours; and his atomic theory, or rather hypothesis, as it should be called, is an endeavour to explain them, by assuming a peculiar ultimate constitution of matter which absolutely necessitates their existence. These laws are based upon one, deeper and more fundamental than themselves, which is assumed in their enunciation, and is to the following effect:—*The same compound consists invariably of the same components.* Water, for example, always consists of oxygen and hydrogen; common salt of chlorine and sodium.

1. The first of these laws is designated the law of *definite* or *constant* proportion, by which we understand that the elements forming a chemical compound are always united in it in the *same* proportion by weight. Thus, water not only consists invariably of oxygen and hydrogen, but the weight of oxygen present is always eight times greater than that of hydrogen; or in other words, eight-ninths of the weight of water are always oxygen, and the remaining ninth hydrogen.

It is the same with every compound. Thus, common salt always contains thirty-five parts of chlorine to twenty-three of sodium; marble, twenty-two of carbonic acid to twenty-eight of lime. In virtue of this law, a number can be found for every body, simple or compound, expressing the ratio in which (or in a multiple or

sub-multiple of which) it combines with every other. Any series of numbers may be taken to represent these combining ratios, provided the due proportion is maintained among them, so that the number for oxygen shall be eight times greater than that for hydrogen, that for nitrogen fourteen times greater, and so on, according to the relations which analysis brings out. The scale recognised by Dalton, and used here, makes hydrogen 1, and counts from it upwards.

It must not be forgotten that such tables represent *relative*, not absolute, weights. Of the smallest possible quantity of oxygen which can combine with the smallest possible quantity of hydrogen, we know nothing; all that we are certain of is, that it is eight times greater than that of hydrogen, whatever that be. None of the numbers taken singly has any absolute value; the 16, for example, which in tables of this kind we are discussing stands against sulphur, does not represent 16 grains, 16-millionths of a grain, or any other absolute quantity; its value appears only when it is taken in connection with the number attached to hydrogen, to which the exact arbitrary value of 1 has been given.

As in the analysis of every chemical substance, it must have been assumed that it would prove *definite* in composition, others before Dalton must have been cognisant of this law of constant proportion. Cavendish, in his "Analysis of Water," Bergman, in testing the saturation of the salts, could not fail to see the law that received special attention at the hands of Wenzel, Richter, and Proust, before the year 1792.

2. The second law of combining proportions

brings out the fact that the same elements, in almost every case, combine in more than one proportion to constitute several compounds. This law is named that of *Multiple Proportion*, and shows that when one body combines with another in several proportions, the higher ones are multiples of the first or lowest. To illustrate this, the two compounds of hydrogen and carbon may be cited, and with all the more effect that they were the bodies operated upon by Dalton, and which, indeed, suggested to him the law. In one of these (*olefiant gas*) there are six parts, by weight, of carbon, to one of hydrogen; in the other (*marsh gas* or *fire-damp*), there are six parts of carbon to two of hydrogen; or, the weight of carbon being the same in both, there is exactly twice as much hydrogen in the first as in the second.

The law of *multiple proportion* was specially realised by Dalton from a solitary case—that of the compounds of carbon and hydrogen described above. So strongly did the facts strike Dalton's mind, that he at once predicted the applicability of the law to all kinds of compounds.

In this direction of inquiry, or rather discovery, it is supposed that Dalton was anticipated by Mr William Higgins, who showed the combinations of sulphur with oxygen, one ultimate particle of sulphur and one of oxygen constituting sulphurous acid; and moreover, that in the compound of nitrogen and oxygen the ingredients are to each other as 1 to 1, 2, 3, 4, and 5 respectively. Here was a clear enunciation of the law of multiple proportion, yet the author can hardly have seen the importance, or he would have laboured to the end, and completed the chapter he had so well begun.

His work made no impress on the public mind, and Dalton had not even heard of it till his rediscovery of the law came to be discussed. Had Higgins, as Dr Wilson remarks, seen the value and importance of the law as Dalton saw it, he would have done as Dalton did, who spent ten or twelve of the best years of his life in verifying its truth by analysis of as large a series of compounds as he could possibly compass.

3. "The third law of combination is named that of *Reciprocal Proportion*, and is to the effect, that if two bodies combine in certain proportions with a third, they combine in the very same proportions with each other. Thus sixteen parts of sulphur combine with eight of oxygen, and twenty-seven parts of iron combine with eight of oxygen; but sixteen parts of sulphur is the very quantity that combines with twenty-seven of iron. We may reverse the numbers: eight of oxygen combines with twenty-seven of iron, and sixteen parts of sulphur with twenty-seven of iron; but eight of oxygen is the very number that combines with sixteen of sulphur. Or, a third time, eight of oxygen and twenty-seven of iron combine respectively with sulphur; but twenty-seven of iron is the quantity that combines with eight oxygen."

The theoretical interest attached to this law of reciprocal proportion is of large practical value to the chemist in all his analyses. For instance, if he ascertains the proportion in which one body combines with any other, that, or a multiple, or submultiple of that, is the proportion in which it combines with every other with which it can combine at all.

It is in relation to this law more than to the others

that the combining weights of bodies are named their *equivalents*. This term expresses, in a way no other does, that a certain weight of one body is equivalent to, or goes as far as, a certain but different weight of another, in the construction of a similar compound. One part by weight of hydrogen, for example, goes as far in combining with eight of oxygen to form an oxide as twenty-seven of iron, or 197 of gold. These compounds have all the same value; the weight of oxygen is the same in all, and the 197 parts of gold do not neutralise the eight of oxygen 197 times more effectually than the one of hydrogen does, but only *as* well and with the production of a *similar* compound.

With this law of reciprocal proportion Wenzel's name is honourably associated as far back as the year 1777; yet, for reasons already expressed, little or nothing was heard of his indefatigable labours in this direction. Even his countryman Richter, who began to publish in 1792, and who spent many years in analysing the different salts, with a view of ascertaining the exact weight of acid and base required for mutual saturation, so as to be able to express this by a number attached to each, hardly received recognition at the hands of his contemporaries.

A fourth law of combination has been instituted by Dr Wilson, and though not generally accepted, is nevertheless thought worthy a place in this memoir, from its being advanced by a practical chemist. Dr Wilson called it the law of *Compound Proportion*, which "teaches that the combining proportion of a compound body is the sum of the combining proportions of its components." The combining proportion of

water, for example, is found by experiment to be nine (or a multiple of nine), hydrogen, as before, being taken as unity; but zinc is the sum of eight parts of oxygen and one of hydrogen, its constituents. The equivalent of carbonic acid appears upon trial to be twenty-two; but carbonic acid is found on analysis to consist of six parts of carbon and sixteen of oxygen, which exactly make up twenty-two. The combining weight of lime is twenty-eight; but lime consists of twenty calcium and eight oxygen, which are also twenty-eight.

"This law is of as much interest and practical value as the preceding one, and supplies the chemist with a most important means of checking the results of empirical analysis in the case of compound bodies. The merit of discovering it belongs entirely to Dalton." Other chemists have looked upon this law as part of the general hypothesis, and resting on the ground of experimental evidence; and the late Dr Whewell, Master of Trinity College, Cambridge, in discussing Dalton's atomic theory in the "History of the Inductive Sciences" does not mention or allude to it.

Modern chemistry seeks to determine the constitution of atoms and "the phenomena attendant, both upon the *state of combination*, and the two antithetical processes of atomic analysis and synthesis," and is based on the laws just propounded.

With the exception of the law of constant proportion, these laws were wrought out by Dalton for himself, and were by him first fully made known to the world. Before this discovery chemistry was little more than an empirical art, treating of the *qualities* or properties of bodies; now it is a science possessing

the character of a science of *quantity*.* And as this science of *quantity* has come more and more to the light, it has widened, and made more accurate the range of chemistry as a science of *quality*.

As proving the value of the laws of chemical combination, and the direct application of *quantitative* to *qualitative* chemistry, the manufacture of sulphuric acid, or oil of vitriol, so well known in the arts, may be instanced. Before Dalton's researches, every manufacturer had his own views as to the quantity of sulphur required in the process—a complicated process, resting its operations on the burning of sulphur in leaden chambers—and was apt to persuade himself of his superior management. Now Dalton showed that, adopt whatever quantity of sulphur you may, only a certain portion by weight of sulphur can unite with a certain proportion of oxygen in the air to constitute sulphuric acid, and that to put a larger quantity in the retorts than could be associated with the oxygen, not only did no good, but was a positive waste of material. Hosts of instances of a similar nature might be adduced to prove the great strides made in the pursuit of a real chemistry since the establishment of the laws of combination, or the application of the atomic hypothesis.

Dalton's early inquiries in natural philosophy

* Were it pertinent to this narrative, much might be offered on the apt analogy subsisting between the laws regulating the infinitely great world of the firmament and the infinitely small world of atoms. The *quantitative* method that enters the mind of the chemist seeking to determine the groundwork of his science, and the conception of gravitation by the astronomer discovering the movements of the heavenly orbs, are based on the same method : both depend, as Comte would say, on "weight properly generalised."

would necessarily make him more or less familiar with the opinions held on the atomic constitution of matter by modern physicists and metaphysicians; and possibly his reading of the Greek and Roman authors had given him a notion of the views of Democritus and the Epicureans. However this may be, in framing his views of an atomic theory to illustrate or give effect to his laws of combining proportion, he assumed the existence of certain ultimate particles or molecules possessed of a definite and unchangeable weight, shape, and size. These he called atoms, to signify that they were indivisible; not, however, affirming this absolutely, but indivisible in relation only to the chemical and other disintegrating forces existing in nature, none of which were supposed able to divide them. Thus Dalton viewed the ponderable masses of the different and elementary bodies as consisting of a countless multitude of undivided atoms.

On the shape and size of the atoms Dalton could offer no opinion. From inspecting his diagrams it might be supposed that he looked upon them as spherical. The size of the atoms apparently never entered into his speculations, knowing full well that they were inconceivably small, and altogether beyond the grasp of our senses aided by the highest appliances of art.

Where Dalton's reasonings, based on experimental inquiry, passed beyond the thoughts of all his predecessors, from Newton and Liebnitz down to his own contemporaries engaged in discussing the atomic constitution of bodies, was his introducing the question of weight in his treatment of the ultimate particles.

It was "this stride in advance of all speculators in atomics," and before he had completed his analysis of a score of compounds, that gave him such confidence in propounding his hypothesis "that the ultimate atoms of the elementary bodies do not possess the same, but different weights, and that the difference between their weights is identical with that which subsists between the combining proportions of the elements themselves."

He could not, of course, pronounce any opinion on the absolute weight of atoms, millions of the heaviest of which might not affect the most delicate balance; but he thought that if it were possible to weigh them one by one, we should find that whatever was the absolute weight of any one would be found to be the weight of each of the others of the same kind; thus, if one atom of hydrogen weighed the millionth of a millionth of a grain, each of the hydrogen atoms would weigh the millionth of a millionth also. Again, we should find that all the oxygen atoms were eight times heavier than the hydrogen ones, all the nitrogen fourteen times heavier, all the gold atoms 197 times heavier. In short, as Dr Wilson observes, "the proportion in which bodies combine with each other are supposed to depend upon the weights of the atoms which make them up, and to be identical with them. All the numbers, accordingly, which before the hypothesis is considered represent combining proportions, as soon as it is adopted, come to represent weights of ultimate atoms or atomic weights."

Dalton looked upon the ultimate particles in the act of combination as being brought into closer proximity, or fused together, but in no way losing

their individuality; so that when the compound they form is decomposed, they separate, and reappear with all their original properties. "The smallest possible quantity of water is in this way conceived to consist of one atom of hydrogen and one of oxygen bound together, without loss of the individuality of either, by the unknown and invisible tie which we term chemical affinity."

This brief exposition, divested as far as practicable of unnecessary technicalities, may enable the reader to form some notion of Dalton's great discovery. Dalton's views of chemical combination, including both the facts and the hypothesis which expressed and explained them, are generally known as the "Atomic Theory." Dr Wilson observes:—"To Dalton himself, the evidence in support of the existence of ultimate indivisible particles appears to have seemed so conclusive, that he considered the doctrine of atoms in the light of an induction from the data furnished by observation and experiment, and this without reference to any other than purely physical questions. We cannot sufficiently reiterate that he was an atomist before he was a chemist. In his lips, therefore, the name 'Atomic Theory,' was consistent, and had a clear meaning. It was John Dalton's atomic theory of chemical combining proportions; his theory of atoms connected with his discoveries in chemistry, so as at once to account for, and to expound them. To those, however, who cannot by any process of generalisation establish to their own satisfaction, or to that of others, the actual existence of atoms (and it includes almost every one who thinks on the subject at all), and for whom the

doctrine of atoms is only a questionable, and, we may say, an indifferent hypothesis, Dalton's view is 'an atomic hypothesis of combining proportion.' It matters comparatively little, however, whether we say atomic theory or atomic hypothesis, provided we keep perfectly distinct what is matter of assumption concerning atoms from what is matter of fact concerning laws of combining proportion."

In a subsequent chapter a few words will be offered on the influence of the atomic theory in the development of the science of chemistry, and the mode in which the new doctrine was received by the contemporaries of Dalton both at home and abroad. In the meantime some recognition should be made of his social life, and his public appearances as a lecturer in London and the larger cities of Britain.

CHAPTER XII.

——— "*For the highest degree of organization*
Gives the highest degree of thought."—PARMENIDES.

PORTRAITURE—SOCIAL HABITS—TEACHING AND ITS REWARDS—LECTURES AT THE ROYAL INSTITUTION, LONDON—HIS RESIDENCE—HIS RETICENCE ON PUBLIC AFFAIRS—LECTURES IN EDINBURGH, GLASGOW, AND LONDON—HIS CORRESPONDENCE ON A VARIETY OF TOPICS.

JOHN DALTON'S stature was slightly above the middle height, say sixty-eight inches. His robust, muscular frame bore considerable resemblance to a class of men daily met with in the agricultural districts of Cumberland. Seen in country garb, and judged from his mere physique, he might have been looked upon as possessing sufficient of the athlete to become a prize-winner in the Carlisle wrestling-ring; nor would his deep, somewhat gruff voice have been an unworthy accompaniment of such bucolic championship. His slight stoop forward, in part arising from his studious and sedentary habits, and unpolished gait, betrayed the absence of physical training; yet after middle age, it appears he could, without a day's preparation, walk as rapidly and continuously as the most disciplined pedestrian; nay, climb the dark brow of the mighty Helvellyn, of three thousand feet, with ease and alacrity.

The real strength and pith of the man lay not in bone and muscle, but in an ample nerve-power and the possession of a fine cerebral development. He had an expressive, thoughtful countenance, and a healthful masculine organisation that could not fail to attract attention. All the portraits of Dalton display a broad, expansive head, bearing no small resemblance to that seen in the engraved portrait of Sir Isaac Newton. And it would appear that the members of the British Association who were present at the Cambridge meeting, in the year 1833, were impressed with Dalton's likeness to Roubiliac's statue of Newton in Trinity College Chapel. Mr Woolley, also an intimate friend of Dalton's, who had a cast of Newton's head placed near Dalton after his decease, has recorded "that the likeness which had been observed during life was in death most striking."

As far as a careful comparison instituted within an interval of four days can be relied upon, I should say the configuration of the head in the statue of Sir Isaac Newton at Grantham resembles very much that of Dalton's standing in front of the Manchester Infirmary. Whether this analogy of form be strictly dependent on the similarity of the crania of the two philosophers, or is in part borrowed from the ideal conception of the sculptors aiming to give breadth to the intellectual organs, is beyond my decision. The statue of Dalton by Chantrey appears to me, both in *pose* and general treatment, one of his best works. The artist, however, has given undue and unnatural prominence to the part of the forehead immediately above the eyebrows. Among other relics of their

accomplished President preserved by the Literary and Philosophical Society of Manchester, is Dalton's hat, from the shape of which it is easy to see that Dalton's head was of the bracycephalic type, with great width across the temples, or in the tranverse axis of the cranium.

The massive, full contour of Dalton's head impresses you with the stamp of intellectual power, and a capacity for the highest of human efforts; and nobly distinctive as it appeared, it was not a whit more noble in form than the brain-structure it enclosed was in fitting response to those claims which science exacts from her more distinguished votaries. His prominent eyebrows shaded in deeper setting eyes of quiet discernment, whilst the use of large spectacles added to his general philosophic seeming and force of character. In his marked nose, rather massive jaws, and firm, deep chin, you saw the features of the sturdy race of the "north countrie," not altogether free of an air of severity at times; these, however, were somewhat toned down by lips less masculine than usual, and a physiognomy that offered blandness as well as firmness and penetration.

The portrait accompanying this memoir is taken from an admirable likeness of John Dalton by Mr J. Lonsdale, engraved by C. Turner, A.R.A. The original picture was in the possession of James Thomson, Esq., F.R.S., of Clitheroe. In preferring Lonsdale's portrait to that by Allen, or the engraving taken from Chantrey's bust, I am guided by those who knew Dalton long and intimately. There are, it is said, other excellent portraits of the philosopher, whose

marked facial lineaments were easily rendered by artists of ordinary distinction.

If his cranium, and forehead especially, had much of the contour and type of Sir Isaac Newton, his general demeanour and scientific methods tallied not a little with what I used to observe of his worthy contemporary, Gay Lussac. This noble Frenchman and true *savant* dressed in country fashion, and steadily held by the subject-matter of his prelections without offering much rhetorical adornment to his science. Perhaps Dalton and Gay Lussac had closer personal and scientific affinities than any two men of their epoch. As it might appear a little incongruous to enter into historical parallels in this brief memoir, I rest content with drawing attention to the cognate scientific relations of Dalton to Berzelius the renowned chemist, and Alexander Von Humboldt the philosopher; both of them possessed the intellectual traits and Teutonic perseverance so markedly seen in Dalton's character. The Swede was the faithful historian and honest exponent of his science, over which his friend Dalton had thrown a halo of light; the German traveller had the keen grasp that could embrace the "Principia" of Newton, the atomic theory of Dalton, and all the ancient and modern philosophies bearing on the elucidation of natural phenomena.

Dalton dressed in Quaker's costume, wearing knee-breeches, dark-grey stockings, and buckled shoes, the fashion of that day. He always appeared in neat attire and good broadcloth, with gloves, gaiters, and a handsome walking-cane, headed or not with silver or gold. His broad-brim beaver showed the finest texture, and his white neckcloth was spotless. He

did not invariably adopt the phraseology of "Friends" by addressing individuals as "thou" and "thee;" nor was he quite so formal in other ways as the old-fashioned representatives of his religious denomination. In general society he was somewhat reserved, and as a good listener, not much disposed to break the line of conversation unless he could do so succinctly, and with a word or two of dry humour that generally told very happily. Considering his self-possession, to which he was to the manner born, he did not appear to advantage in miscellaneous groupings of people, and still less amid the gatherings of the *élite* and philosophic of the metropolis. This apparent deficiency in his mental manifestations arose from his bringing up, his want of social opportunities, and his comparatively little intercourse with men and women of high culture. When placed among his own circle, and encouraged to certain trains of thought favouring his tendency to exposition, he had no difficulty in sustaining an animated conversation, and at the same time greatly interesting his hearers. His colloquial faculty was at its best over a pipe of tobacco, surrounded by two or three friends in an evening: then he was at home, and felt as a philosopher who had something to say, and could say it well. As a general rule, he exhibited much of the golden silence so vauntingly preached by Thomas Carlyle, but so seldom practised by that great historian, whose loquacity is rather a paramount feature in his social fraternisations.

John Dalton enjoyed the constantly happy privileges attendant on a healthy organisation, scarcely experiencing even a day's illness, excepting from

adventitious circumstances, such as the porter-poisoning in London to be presently noted, or an attack of the prevailing epidemic, influenza. He had a good pulse and a good digestion,* and these constitute nine-tenths of the groundwork of a man's success in the world of competition. How great soever the mental gifts may be in an individual, the exercise of them remains more or less in abeyance under the dark clouds of dyspepsia, and other ills to which human flesh is heir. No puny-framed person has reached the higher honours of statesmanship, and no bilious phlegmatic lawyer, as far as I know, has attained the woolsack. The men of eminence who have figured in history, be they soldiers, philosophers, physicists, or others, have been strong-stomached, or, as Paley, who was a true example of the kind, used to say, good trencher men. Dalton's organic functions, aided by balmy sleep, went on *pari-passu* with his prescribed mental labours and laboratory work. Calmness and serenity ruled the mind as equality governed the bodily operations of the philosopher. He ate moderately, and generally drank only water, even in his old age, when, if ever, the most temperate of men may stand in need of wine and stimulants.

There are but faint tracings of historical interest in the life of a man who had to pursue the calling of a

* No class of people in Her Majesty's dominions look more attentively to their victuals than the worthy Society of Friends, whose daughters are neat cooks and dainty purveyors. Dalton was a true Friend, who, on his journeying from home, seldom omitted to note his stomach supplies, and what they cost him. Thus he wrote :—"Mr J. Pearson and I walked to Hayfield (four miles), breakfasted there on tea, two basins of milk, four eggs, bread and butter, muffins, &c. : for what?—for 9d. a piece !"

schoolmaster, and to practise the sedate virtues of a bachelor Quaker, whose walk was mainly confined to a circle neither enlivening in tone nor brilliant in social qualities. Dalton's life was truly in his works, his science, and his discoveries; in any other direction it was monotonous in form and details, and most uneventful in character. Each day of the week, except the first (Sunday), found him engaged teaching grammar, arithmetic, and caligraphy, or lecturing on physics and chemistry to more advanced students. It is true, he had grown up with this kind of occupation from a very early age, and apparently felt it the most suited to the habits and contemplative moods of his mature years. Teaching was the sustentation fund of both his virtues and his philosophies; and he showed his wonted sagacity in holding on by the essentials of life, for, as an Englishman of obscure birth, what could he expect, or what has science ever obtained, at the hands of the so-called paternal government of this great country? My genial and lamented companion of other days, Professor Edward Forbes, used to reply to such a query, "More kicks than ha'pennies, my friend!"

His ordinary fees for instruction were at first one shilling; then eighteenpence; and at a later period of his life he exacted half-a-crown. He earned a few guineas as a "professional chemist," making the low charge of half-a-guinea for an ordinary chemical analysis showing the different constituents to be found in a gallon of water: the same kind of work to-day would fetch ten guineas. For special instruction in the laboratory, or practical chemistry, his fee was 3s. 6d. With the increased demand for his services arose a

higher remuneration; so that after his sixtieth year his pecuniary means were ample. The story is told of Dr Bardsley, a Manchester physician of eminence, calling once on Dalton, and observing half-a-crown lying on the table, said, "You throw your money about carelessly." "Ay," replied Dalton, "a woman has just gone away that I have been teaching a bit of arithmetic to, and thou see she has left me half-a-crown."

The mode by which he earned a livelihood became after long years of pursuit so essentially a part of his nature, that he had no disposition to cast it aside when by dint of success he had gathered a modest independence. To follow a settled course, that in time lapsed into a regular groove of thought as well as of action, was characteristic of Dalton, who claimed for perseverance a place among the highest of virtues in a man's career, the main step in the ladder of progress, and the promotion of a life's well-doing. He was a twin brother in sentiment with the monk of old whose motto was *Laborare est orare*—a text that Dalton typified in a high degree in his course through the world. Energetic and laborious, and quietly pushing along the road to material prosperity, he might hope for the verification of the saying—"If thou dost well unto thyself, all men will speak well of thee." *

Schoolmastering was less of a drudgery to him

* The schoolmasters in the days of palmy Rome occasionally got a remunerative *quid pro quo* for their services to youth, in enjoying official positions worthy of the best men in the commonwealth. The Emperor Vespasian, though no scholar himself, had sense to see that it was for the public good that men of letters should be encouraged; and he caused Quintillian, one of the most successful teachers of the day, to be elevated to the Consulship.

than to most persons of his class; for having set his pupil to his tasks, with a general remark as to the mode of pursuing them, he left him very much to do what he best could by persevering exertions, whilst he turned his own attention to chemical experiments, and the calculations naturally arising out of their consideration. Inasmuch as this laboratory work was comparatively little checked by solicitations for help on the part of his scholars, he worked double tides in each diurnal—earning his bread and butter, and at the same time realising the data or foundations upon which he was enabled to erect a grand superstructure of theoretical and practical science.

With all his eagerness in the paths of philosophy, he had sufficient of the shopkeeping Briton in his composition to keep his eye open to the main chance of being able to live prudently well, and to save money to meet the wants and infirmities of old age. This careful procedure was justifiable in his early struggles, when, as a teacher of natural philosophy, he could only realise about £100 a year in one of the great commercial capitals of Lancashire, where opulence so largely abounded. By and by his lectures delivered in the cities of England and Scotland brought considerable grist to the mill, and gave clear promise of further accession of means and sources of independence. Such fortune in prospect did not alter his mode of living; and it is to be feared that his habits of saving, so long practised, got too retentive a hold to be cast aside in the declination of life, when the mind is apt to be disquieted by its prospects of the future. If frugal and economic, to a degree worthy of a fellside patriarch rather than a bachelor of inde-

pendent resources, he was by no means wanting in generosity on a great demand for its exercise; whilst he privately afforded aid to the well-deserving of his old friends in lack of money.

The many valuable memoirs furnished by Dalton to the Literary and Philosophical Society of Manchester between the years 1800 and 1803 called forth a large share of attention both at home and abroad. In proof of which the Directors of the Royal Institution of Great Britain, consisting of Count Rumford, the founder, of Humphrey Davy, Dr Wollaston, and others eminent in science and literature, invited Dalton to deliver a course of lectures to the members of the institution. These lectures embraced mechanics and physics, and inaugurated the session 1803–4. Dalton's first appearance before a London audience was on December 22, 1803.

In a letter to Mr John Rothwell we get more knowledge of his London experiences:—

LONDON, *January* 10, 1804.

I was introduced to Mr Davy, who has rooms adjoining mine in the Royal Institution. He is a very agreeable and intelligent young man, and we have interesting conversations in an evening. The principal failing in his character is that he does not smoke. Mr Davy advised me to labour my first lecture; he told me the people here would be inclined to form their opinion from it. Accordingly I resolved to write my first lecture wholly, to do nothing but to tell them what I would do, and enlarge on the importance and utility of science. I studied and wrote for nearly two days, then calculated to a minute how long it would take me reading, endeavouring to make my discourse about fifty minutes. The evening before the lecture, Davy and I went into the theatre; he made me read the whole of it, and he went into the furthest corner; then he read it, and I was the audience. We criticised upon each other's method.

Next day I read it to an audience of about 150 or 200 people, which was more than was expected. They gave a very general plaudit at the conclusion, and several came up to compliment me on the excellence of the introductory. Since that time I have scarcely written anything; all has been experiment and verbal explanation. In general, my experiments have uniformly succeeded, and I have never once faltered in the elucidation of them. In fact, I can now enter the lecture-room with as little emotion nearly as I can smoke a pipe with you on Sunday or Wednesday evenings.

On his returning to Manchester at the end of January, he wrote as follows to his brother:—

February 1, 1804.

DEAR BROTHER,—I have the satisfaction to inform thee that I returned safe from my London journey last seventh day (Saturday), having been absent six weeks. It has, on many accounts, been an interesting vacation to me, though a laborious one. I went in a great measure unprepared, not knowing the nature and manner of the lectures in the institution, nor the apparatus. My first was on Tuesday, December 22d (1803), which was introductory, being entirely written, giving an account of what was intended to be done, and natural philosophy in general. All lectures were to be one hour each, or as near as might be. The number attending were from one to three hundred of both sexes, usually more than half men. I was agreeably disappointed to find so learned and attentive an audience, though many of them of rank. It required great labour on my part to get acquainted with the apparatus, and to draw up the order of experiments and repeat them in the intervals between the lectures, though I had one pretty expert to assist me. The scientific part of the audience was wonderfully taken with some of my original notices relative to heat, the gases, &c., some of which had not before been published. Had my hearers been generally of the description I had apprehended, the most interesting lectures I had to give would have been the least relished; but as it happened, the expectations formed had drawn several gentlemen of first-rate talents together, and my eighteenth, on heat, and the cause of expan-

sion, &c., was received with the greatest applause, with very few experiments. The one that followed was on *mixed elastic fluids*, in which I had an opportunity of developing my ideas that have already been published on the subject more fully. The doctrine has, as I apprehended it would, excited the attention of philosophers throughout Europe. Two journals in the German language came into the Royal Institution whilst I was there, from Saxony, both of which were about half filled with translations of the papers I have written on the subject, and comments on them. . . .

In lecturing on optics, I got six ribbands—blue, pink, lilac, and red, green, and brown—which matches very well, and told the curious audience so. I do not know whether they generally believed me to be serious, but one gentleman came up immediately after, and told me he perfectly agreed with me: he had not remarked the difference by candle-light.

Towards the close of the year 1805, he went to reside in Faulkner Street, at the house of the Rev. William Johns, with whom he continued to lodge and board for the greater part of his life. Miss Johns has thus recorded the characteristic simplicity with which this engagement was formed:—"As my mother was standing at her parlour window one evening towards dusk, she saw Mr Dalton passing on the other side of the street, and on her opening the window, he crossed over and greeted her. 'Mr Dalton,' said she, 'how is it that you so seldom come to see us?' 'Why, I don't know,' he replied, 'but I have a mind to come and live with you.' My mother thought at first that he was in jest; but finding that he really meant what he said, she asked him to call again the next day, after she should have consulted my father. Accordingly he came and took possession of the only bedroom at liberty, which he continued to occupy for nearly thirty years. And here I may mention to the

honour of both, that throughout that long connection he and my father never, on any occasion, exchanged one angry word, and never ceased to feel for each other those sentiments of friendly interest which, on the decline into years of both, ripened into still warmer feelings of respect and affection."

No one ever worked more methodically or lived more regularly than Dalton did during his long and happy residence with the family of Mr Johns. He rose at eight o'clock in the morning; if in winter, went with his lantern in his hand to his laboratory in the rooms of the Literary and Philosophical Society, and not above two minutes walk from his lodgings, lighted the fire, and came over to breakfast when the family had nearly done. Went to the laboratory, and stayed till dinner-time, coming in in a hurry when it was nearly over, eating moderately, and drinking water only. Went out again, and returned about five o'clock to tea, still in a hurry, when the rest were finishing. Again to his laboratory till nine o'clock, when he returned to supper; after which he and Mr Johns smoked a pipe, and the whole family seems much to have enjoyed this time of conversation and recreation after the busy day.

A lady, whose bedroom commanded a view of Dalton's laboratory, always knew the morning hour to a minute by observing him noting the condition of his thermometers outside his window. It was by exercising the same methodical habits that enabled him to accomplish so much real work. Literally everything went on like clockwork with him from day to day; even the few hours of recreation he snatched in the week were guided by rule and habit.

As a boy, he enjoyed rustic amusements, among which a game at bowls was deemed as innocent as any; and in Manchester he attended a bowling-club which met regularly every Thursday afternoon at a tavern at Broughton and at Stretford, where he played with all the zest and earnestness of a young man, watching the movements of the bowls, and swaying his body to and fro in accordance with their direction and speed. After the game was over, upon which some moderate betting took place, tea was served; and in the evening the members, with the exception of Dalton, who did not know a king of spades from a knave of hearts, played whist; whilst all enjoyed the fragrant weed, smoking, as was the fashion in those days, long churchwarden pipes. After "blowing a big cloud," Dalton left the snug parlour of the "Dog and Partridge," returned to town, and of course to his laboratory, to note the state of his barometer and thermometer. On being questioned as to his reasons for selecting Thursday for his country amusement, he replied that he liked his Saturday holiday in the middle of the week.

He would occasionally spend a few minutes in reading the newspapers, the politics of which do not seem to have interested him very greatly, or he would have shown less reticence on public affairs. Mr Johns and his family thought him Toryish in principle; others maintain that he was a Whig, as almost all true and well-educated Quakers are. His manhood was developed during the most eventful era in European history—French revolutions and terrorism; Napoleonic wars abroad, and English radicalism at home—yet in none of his letters to his

brother and friends does he allude to the great changes affecting the ancient dynasties, or the threatened disorganisation of the interests of society at large.

How differently did Dalton comport himself, and wisely, too, compared with his French contemporaries Berthollet, Monge, Arago, Raspail, who entered conspicuously into all the turmoil of politics, as ready to ascend the tribune, and to raise their voices and swords against aristocratic rule, as to determine the nature of a chemical salt, or to measure an arc of the meridian.

Reflecting on his position as a teacher, naturally involving comment on modern as well as ancient history, and not less his religious affinities and the stirring times in which he lived, his reserve on questions of deep and lasting interest to his species appears somewhat remarkable. Though by no means a recluse in habit like Cavendish, nor a dreamy philosopher like Spinoza, he seems to have bestowed little or no thought upon the current topics of the day—political or philanthropic; or, if he entertained any opinions thereon, he refrained from expressing them. Nor did he engage in the metaphysical or purely philosophical questions agitating the leading minds of Europe, the discussion of which brought the views of Locke, Hobbes, and Hartley, and those of the Scottish school of philosophy, headed by Hume, in competition with the Cartesians and the Cyclopædists abroad. He was not a many-sided, but rather a single-minded man, who concentrated all his energies on his favourite studies—chemistry and meteorology, and both were closely allied. The occasions on

which he was induced to deviate from his own special path of meditative culture were so rare as not to be worth naming. His life was spent in his laboratory almost to the exclusion of all other pursuits, be they patriotic, or moral, or political in aim. It is said that, when urged to come more into the world, and to take part in matters of real public interest, that he replied in the words he made use of when asked why he did not get married ?—"Oh ! I never had time."

He manifested much kindly good-will towards his friends and old Cumbrian acquaintances, and liked to promote the sociable relations of his Manchester visiting circle ; but his sympathies were hardly catholic enough to include the joys and griefs of the world outside his own, or the larger interests of humanity. He adhered to his social groove, and that was pretty Quakerish, in the same rigid way that he stuck to his scientific calling. He wanted academic culture, and the refined thought that tends to ennoble men, be their walk what it may in life—nay, seemed proud of his broad Cumbrian dialect and plainness of speech. No mention is made of his being a reader of history or *belles-lettres*, and there is nothing to indicate his having given much consideration to the influences exercised by the leading minds either of the Elizabethian historical period, or by the poets and writers in whose hands a graceful literature flourished in the century of his birth.

Attention has already been directed to the circumstance of Dalton showing but little regard for any kind of reading—be it historical, geographical, or scientific—even at a time when his contributions to the Literary and Philosophical Society of Manchester

were numerous, and his "Meteorological Essays" and "New System of Chemistry" were cast before the public for no other purpose than being consulted. He acted in this respect as if he were a light to his own path beyond all other lights visible or attainable. And what is more incongruous and inconsistent with the character of a man aspiring to a keen grasp and comprehension of all available knowledge, he seems to have discouraged reading in others. On the council of the Philosophical Society he stood in the way of acquiring the kind of library suited to so cosmopolitan an institution, and was in the habit of saying to the remonstrances of those who inculcated the introduction of good works and in good quantity, "I could carry all the books I have ever read on my back!"* He was not aware that he was in part reproving himself by this statement, inasmuch as more careful reading, and the wish for higher culture, would have added vastly to his own resources, and given breadth and light to the needful literary exposition of his scientific work.

Dalton's first appearance in North Britain, his impressions of Edinburgh and the reception he met with there, and in Glasgow as a lecturer, may be gathered from his letter to Mr Johns, who was looking after Dalton's schoolmastering interests in Manchester.

EDINBURGH, *April* 19, 1807.

RESPECTED FRIEND,—As the time I proposed to be absent is nearly expired, and as my views have recently been somewhat

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* His stock of books, as early as the year 1800, were beyond the power of any man's back. Note is made of them in a subsequent page, in discussing the character and amount of his chemical and other apparatus.

extended, I think it expedient to write you for the information of inquirers. Soon after my arrival here I announced my intention by advertisement of handbills. I obtained introduction to most of the professional gentlemen in connection with the college, and to others not in that connection, by all of whom I have been treated with the utmost civility and attention. A class of eighty appeared for me in a few days. My five lectures occupied me nearly two weeks. [Owing to several persons being disappointed in not hearing him, Dalton arranged a second course.]

. . . .

Hitherto I have been most highly gratified with my journey; it is worth coming 100 miles merely to see Edinburgh. It is the most romantic place and situation I ever saw; the houses touch the clouds. At this moment I am as high above the ground as the cross of St James's spire; yet there is a family or two above me. In this place they do not build houses side by side as with you, they build them one upon another—nay, they do what is more wonderful still, they build one street upon another; so that we may in many places see a street with the people in it directly under one's feet, at the same time that one's own street seems perfectly level and to coincide with the surface of the earth. My own lodgings are up four flights of stairs from the front street, and five from the back. I have just 100 steps to descend before I reach the real earth. I have a most extensive view of the sea. . . . The walks about Edinburgh are most delightfully romantic. The weather is cold; ice every morning, and we had a thick snow a few days ago. Upon walking up on to an eminence, I observed all the distant hills white, the nearer ones speckled. I saw five or six vessels just touching the horizon; they seemed to be about ten or twelve miles off, and their white sails looked like specks of snow on the sea. I saw a dozen or two at anchor in the river, and a most charming view of the Fifeshire hills on the other side of the Forth. Adieu. My best regards to you all.

J. DALTON.

He gave a second course of lectures to the Royal Institution of Great Britain in 1809, and in December of that year addressed the following letter to Mr

Johns, in which there is a curious mingling of potatoes and philosophy, with an eye to Bond Street fashions and pretty women :—

On Tuesday I spent greater part of the day (morning, they call it here) with Mr Davy in the laboratory of the Royal Institution. Sir J. Sebright, M.P., who is becoming a student of chemistry, was present. On Wednesday I attended Mr Bond's lecture on astronomy, and prepared for mine the next day. On Thursday, at two, I gave my first lecture. Mr Pearson, a former acquaintance, went home with me after the lecture, and we had a long discussion on mechanics. Mr Davy had invited me to dine with the club of the Royal Society at the Crown and Anchor at five o'clock ; but I was detained till nearly six. I got there, and called Davy out. All was over ; the cheese was come out. I went, therefore, to the nearest eating-house I could find to get a dinner. Looking in at a window, I saw a great heap of pewter plates, and some small oblong tables covered with cloths. I went in and asked for a beefsteak. "No." What can I have? "Boiled beef." Bring some immediately. There was nothing eatable visible in the room, but in three minutes I had placed before me a large pewter plate covered completely with a slice of excellent boiled beef swimming in gravy, two or three potatoes, bread, mustard, and a pint of porter. Never got a better dinner. It cost me 11½d. I should have paid 7s. at the Crown and Anchor. I then went to the Royal Society, and heard a summary of Davy's paper on chemistry, and one of Home's on the poison of the rattlesnake ; Sir J. Banks in the chair. Davy is coming very fast into my views on chemical subjects. On Friday I was preparing for my second lecture. I received a visit from Dr Roget. On the evening I was attacked with sore throat. I sweated it well in the night with clothing, but it was bad on Saturday, and I was obliged to beg a little indulgence of my auditors on the score of exertion. However, I got through better than I expected. I kept in on Sunday and Monday and got pretty well recruited. On Tuesday I had my third lecture, after which I went to dine at a tavern to meet the Chemical Club. There were five of us, two of whom were Wollaston and Davy,

secretaries of the Royal Society. We had much discussion on chemicals. Wollaston is one of the cleverest men I have yet seen here. To-day, that is Thursday (for I have had this letter two or three days in hand), I had my fourth lecture. I find several ingenious and inquisitive people of the audience. I held a long conversation to-day with a lady on the subject of rain-gauges. Several have been wonderfully struck with Mr Ewart's doctrine of mechanical force. I believe it will soon become a prevalent doctrine. I should tell Mrs J. something of the fashions here, but it is so much out of my province, that I feel rather awkward. I see the *belles* of New Bond Street every day, but I am more taken up with their faces than their dresses. I think blue and red are the favourite colours. Some of the ladies seem to have their dresses as tight round them as a drum, others throw them round like a blanket. I do not know how it happens, but I fancy pretty women look well either way.

I am very regular with my breakfast, but other meals are so uncertain that I never know when or what. Hitherto I have dined at from two to seven o'clock ; as for tea, I generally have a cup between nine and ten, and, of course, no supper. I am not very fond of this way of proceeding. They say things naturally find their level, but I do not think it is the case in London. I sent for a basin of soup the other day before I went to lecture, thinking I should have a good threepenny-worth, but I found they charged me one shilling and ninepence for a pint, which was not better than some of our Mary's broth. Of course, I could not digest much more of the soup.

Another letter, similarly addressed, shows the narrow escape that Dalton had from lead-poisoning in the use of his favourite beverage—porter.

LONDON, *January* 29, 1810.

You may perhaps have heard from Dr Henry that I have been nearly as ill as formerly, that I have been nearly poisoned since I came here. I had been about three weeks when I discovered it was the porter which produced the effects. I

have not had a drop since, and have never had any more of the symptoms. [This was owing to the presence of lead in the porter drawn through leaden pipes at the bar of the public-house.]

I have had a pretty arduous work, as you may imagine, having had three lectures to prepare each week, to attend two others, and to visit and to receive visits occasionally besides. I find myself just now in the focus of the great and learned of the metropolis. On Saturday evening I had a discussion with Dr Wollaston, and a party at Mr Lowry's. On Sunday evening, last night, I was introduced to Sir Joseph Banks, at his house, by Sir John Sebright. Sir Joseph said, "O Mr Dalton, I know him very well; glad to see you; hope you are well," &c. There were forty or more of the leading scientific characters present, many of whom were my previous acquaintances, such as Sir Charles Blagden, Drs Wollaston, Marcet, Berger, and Roget; Messrs Cavendish, Davy, Tennant, Lawson, &c. We had conversation for about an hour or more in Sir Joseph's library, when the company dispersed. To judge from the number of carriages at the door it might be a court levee.

I paid a visit, in company with Dr Lowry, to Dr Rees, the other day; we spent an hour in conversation in the doctor's library. The doctor seems a worthy philosopher of the old school; his evening lucubrations are duly scented with genuine Virginia.

From all that can be learned of Dalton's mode of lecturing, it would appear that his facts and experiments were more worthy of approval than either his manner or his language. London audiences were accustomed to listen to the eloquence of Davy, and the academic exposition of Wollaston and other celebrities; so that Dalton could hardly expect the laudation of critics. One of them, a writer in the *Quarterly Review*, vol. xcvi., said, "His voice was harsh, indistinct, and unemphatical, and he was sin-

gularly wanting in the language and power of illustration, needful to a lecturer on these high matters of philosophy, and by which Davy and Faraday had given such lustre to their discoveries. Among other instances of his odd appropriation of epithets, we recollect that in treating of oxygen, hydrogen, nitrogen, &c., those great elements which pervade all nature, he generally spoke of them as *these articles*, describing their qualities with far less earnestness than a London linendraper would shew in commending the very different *articles* which lie on his shelves."

CHAPTER XIII.

"*The character of the true philosopher is to hope all things not impossible, and to believe all things not unreasonable.*"—SIR JOHN HERSCHEL.

VISIT FROM M. PELLETAN—DALTON'S APPARATUS—CHEMICAL PROGRESS—GAY LUSSAC'S LAW OF COMBINATION BY VOLUME—DALTON'S OBSTINACY—ROYAL SOCIETY—NEW SYSTEM OF CHEMICAL PHILOSOPHY—ACADEMY OF SCIENCES—POLAR EXPEDITION—VISITS PARIS UNDER HAPPY AUSPICES.

MONS. PELLETAN of Paris visited Manchester in 1820, for the sole purpose of paying his respects to the founder of the atomic theory. He fancied that Dalton would be occupying a professor's chair, surrounded by adepts in science and hundreds of ingenuous youths; residing in a handsome mansion in a handsome square of the city, or enjoying his *otium cum dignitate* in a suburban villa, with roses embellishing its porch; in short, the great representative man of Manchester, and well-known and appreciated by every citizen. Judge of his surprise when *Monsieur Dalton, le philosophe,* could only be found after much inquiry, and when found, was engaged looking over the shoulders of a boy figuring numbers on a slate. The Frenchman, doubting his senses, asked the grey-headed gentleman if he really had the honour of addressing *Monsieur Dalton.* "Yes," replied Dalton; "will you sit down till I put this lad right about his arithmetic." "What! a philosopher of European fame acting as schoolmaster—

impossible!" As the stranger gathered confidence, he asked Dalton's permission to see his laboratory and philosophical instruments, the employment of which had led to such remarkable discoveries in physics. "Oh," said Dalton, pointing to a miscellaneous collection of apparatus, occupying a corner of the room not much larger in area than what, in Mrs Gamp's eye, would be needful for the reception of an infant's cradle, and the appurtenances thereunto belonging, "that's all the apparatus * I possess."

M. Pelletan might well be astonished on seeing the humble lodging of the philosopher, who pursued the vocation of schoolmaster, and who had with such meagre apparatus determined so many knotty points in the history of chemistry. He returned to his own

* The bulk of Dalton's apparatus, both that employed in his researches, and that used for illustrating his lectures, is carefully preserved in the rooms of the Literary and Philosophical Society, of which society he was so long the ornament. These fill a large glass case, and could not by any possibility have been thrust into the corner of the biggest room in the Institution. Why Dalton should have spoken to others as well as M. Pelletan in so depreciating a tone of his instruments of research, is only explicable on the grounds of his wishing to show that, unlike other experimentalists, he did not rely on intricate and costly tools for the carrying on of his scientific investigations. He used to indulge in the same disparaging comments on the quantity of books in his possession, saying that he "could carry them all on his back." Considering Dalton's accuracy of statement on all matters, it is curious to note in his catalogue of books, made in 1800, that he then possessed a good collection of works on chemistry, natural philosophy, mathematics, classics, history, and *belles lettres*, &c. In the same year he took stock of his philosophical instruments, and recorded under different headings:—"Electrical, Magnetic, Optical, Hydrostatical, Botanical, Astronomical, Chemical, Meteorological Apparatus; Mathematical and Mechanical Utensils and Tools;" also, "Phonic and Musical Apparatus." This collection must have been greatly supplemented before M. Pelletan's visit in 1820.

country thankful to know that France could recognise her men of science in a spirit worthy of an enlightened age; nor was he less indignant that rich and boastful England permitted the greatest of her sons to waste his strength in practising the common duties of a common schoolmaster. England had spent 800 millions sterling in upholding a rotten Bourbonic dynasty, but could not afford £200 a year to the man whose scientific discoveries had made her name known to the ends of the civilised world.

Few things in Dalton's remarkable career as an experimentalist were more surprising than the crudeness of his chemical apparatus. Among other economic chemical contrivances, he used his empty *penny* ink-pots, through the corks of which he inserted glass tubes of less than a farthing value. And no doubt he turned these to good account. If the reader will refer to the appendix containing a list of his works and contributions to chemical science, he cannot fail to be struck at the amount of work achieved by Dalton with such simple means.

Dalton read no less than one hundred and sixteen essays to the Literary and Philosophical Society of Manchester. These essays, it must be admitted, though original and suggestive in aim, are of unequal merit. Some are worthy of his best days, but the majority were got up for the purpose of meeting the wants of the society. It should be observed that the higher office-bearers of every scientific society are bound to do their best to render their society worthy of public regard; and as the contributions of members are often irregularly offered, it behoved Dalton to be ready with a paper when the programme

of the meeting seemed less attractive than usual. In addition to the large number just named, he made various contributions to the scientific journals of the day; thus, he furnished twelve essays to *Nicolson's Journal*, seven essays to Thomson's "Annals of Philosophy," and one to Phillip's "Annals of Philosophy;" three papers to the *Philosophical Transactions*, and one to the "Annales de Chimie." Of weightier import, as embracing much that appeared in an isolated form, were his editions of his "New System of Chemistry," and his "Meteorological Essays and Observations."*

Then it ought to be borne in mind that this array of chemical volumes, and essays, and fragmentary papers were the mental offspring of a man whose time was not at his own disposal; he had to labour for his daily bread, and this could only be obtained by devoting the best part of each day to the vocation of schoolmastering.

At a later period of his career, about the year 1840, when he took offence at the refusal of the Royal Society to insert his "Essay on the Phosphates and Arseniates," he printed it in a separate form, with the indignant comment, "Cavendish, Davy, Wollaston, and Gilbert are no more;" and concluded by saying, "I intend to print my essays in future to be appended to my other publications." Accordingly he printed four short essays, viz., "On Microcosmic Salt;" "On the

* These valuable scientific works were little heard of outside the strictly professional circle. On December 22, 1800 (seven years after their issue), Dalton records—"It appears that my 'Meteorological Essays' have cost nearly £45; that 300 have been sold for £45, that 33 have been given away or lost, and that 417 remain on hand."

mixture of Sulphate of Magnesia and the Biphosphate of Soda;" "On the quantity of Acids, Bases, and Water in the different varieties of Salts, with a new method of measuring the Water of Crystallisation, as well as the Acids and Bases;" and "On a New and Easy Method of analysing Sugar." Dr Henry says "the last two announce a discovery of considerable importance." Dalton found that certain salts, rendered perfectly anhydrous by heat, when dissolved in water, caused no increase of its volume, showing that the salt enters into the pores of the water; also that salts containing water, when dissolved in a measured quantity of pure water, increased the volume of the solvent by a quantity precisely equal to their constituent water, the solid matter, as before, entering the pores of the water. Sulphate of magnesia was the subject of several experiments; but he adds, "I have tried the carbonates, the sulphates, the nitrates, the muriates or chlorides, the phosphates, the arseniates, the oxalates, the citrates, the tartrates, the acetates, &c., &c., and have been uniformly successful; only the water adds to the *bulk*, and the solid matter adds to the *weight*. This fact," he continues in his last paper on sugar, "was new to me, and I suppose to others. It is the greatest *discovery* that I know of next to the atomic theory." He proceeds to apply this new principle to the analysis of sugar.

These views of Dalton's, though regarded at first as more or less imperfect, were nevertheless confirmed by Gay Lussac and Thenard, and in a remarkable manner by Dr Lyon Playfair and Mr Joule.*

* The subject is fully discussed by Dr Henry, p. 194, &c.

To attempt the briefest review of Dalton's numerous works would require a volume equal to the present; moreover, such laborious investigations as his, extending over a period of forty years, can only claim the consideration of the man of science pursuing similar paths of inquiry, or the enthusiastic, or rather the cyclopædic, historian. Much of his work, it ought to be remarked, is rendered valueless to-day by the great strides made in the domain of analytic chemistry during the last thirty years. Chemistry has mightily changed, and is daily changing its operations as these affect both the organic and inorganic kingdoms, and is prepared, as Dr Samuel Brown said a quarter of a century ago, "to cast its light into the subterraneous physics (to borrow the title of Beccher's chaotic *opus*) of geology, and into the still more secret physics of physiology, pathology, therapeutics, all its gifts and promises being, even ostentatiously, fraught with practical benefits and intentions. In short, notwithstanding the prowess of Herschel and the astronomers, or of Cuvier and the naturalists, and notwithstanding the presence of such questioners as Maedler and Owen, chemistry is the science of the century; and that, not by any means for what has yet been done or conceived in it, nor yet for the unprecedented conquests which the chemists are making ready to attempt with success, but because there are sciences at work which cannot advance a step farther, we do not say in mere breadth, but in depth, until this eminently terrestrial yet cosmical and ideal science be carried nearer perfection."

"Dalton," writes Dr Henry, "was not great in

experimental chemistry. It may be urged that, as a chemist, he was entirely self-taught, and commenced his labours at a time when the resources of the experimentalist were scanty and imperfect. Yet there must have been some inherent deficiency in his mental or manual endowments disqualifying him for accuracy in experimenting. For his great *contemporary*, Berzelius, created for himself, and through his numerous pupils for Europe, that system of exact analysis, based upon an infinitude of minute precautions—upon rigid weighings, upon vigilant washings on the filter, upon the greatest attainable purity of reagents—which has raised chemistry to its present rank among the experimental sciences. Davy and Gay Lussac, too, not many years his juniors, working simultaneously with him in the same mighty era of chemical progress, devised for themselves instruments and processes of research susceptible of extreme precision. If we compare the experimental researches of Dalton detailed in his New System, 1810, and in subsequent special chemical memoirs, with the marvellous discoveries revealed in rapid succession in the years 1807–11 by the genius of Davy, and recorded in those masterworks of investigation, his 'Bakerian Lectures,' or with the somewhat later transcendent monographs of Gay Lussac on cyanogen, iodine, and the compounds of nitrogen—eternal monuments of exact and exhaustive chemical working—we cannot hesitate to admit Dalton's vast inferiority in experimental chemistry. Nature, it would seem, with a wise frugality, averse to concentrate all intellectual excellences in one mind, had destined Dalton exclusively for the lofty rank of a lawgiver of chemical science."

In acknowledging the justice of the foregoing criticism, it is curious to note that, like Black, Cavendish, Priestley, and Lavoisier, Dalton sought the more arduous paths of his science, by making the chemistry of the gases his special study. Luckily for him, he began his chemical career when the phlogiston phantom that troubled his predecessors was vanishing like the dim twilight before the rising sun of another day in science, that of positive chemistry. Dalton did not consider himself bound by the prescriptive rights of antiquated *doctrinaires*, or even the current credentials of his contemporaries; but entering upon the great field of chemistry, unshackled by traditions and beliefs, he pursued his own method of culture and cropping. His innovations upon the old lines of conservative chemistry must have been as disturbing to some of the old-fashioned followers, as Sir H. Davy's discoveries of the nature of the oxides were to the old Aberdonian professor who "couldna be fashed" to notice them. At length, impelled by the entreaties of his colleagues to place his pupils *au courant* with the latest discoveries in science, the professor made a compromise of his opinions by observing to his class, in the following Scottish manner—"Both potash and soda are now said to be metallic oxides—the oxides, in fact, of two metals called potassium and sodium—by the discoverer of them, *one* Davy, in London—a varra troublesome person in chemistry."

Within a year of Dalton's issuing his "New System of Chemical Philosophy," Gay Lussac published an important memoir on the law of combination of the gases by volume in equal or multiple proportions,

which law appeared to furnish strong support to the atomic theory. Unaccountably as it may appear, Dalton, instead of welcoming the precise experimental results of Gay Lussac, offering as they did such valid confirmation of his own doctrines, raised various objections to them, and apparently never gave in his adhesion to the view so ably and correctly enunciated by his French contemporary. All the great chemists of the day sanctioned the words of Berzelius on this question—"If we substitute the term atom for volume, and contemplate bodies in the solid instead of the gaseous state, we find in the discovery of Gay Lussac one of the most immediate proofs in favour of this hypothesis of Dalton." And as Dr Henry observed, "The simple relation discovered by Gay Lussac was independent of, and supplemental to, that revealed by Dalton." It was so treated by Dr Prout in his masterly essay ("Annals of Philosophy," vol. vi., 1815), and has been since universally thus regarded. Moreover, Dalton himself, in determining the important atomic weight of water (vol. i., p. 275), bases his calculation on the experiments of Humboldt and Gay Lussac, and concedes the fact (though at a later period he doubted it) that two measures of hydrogen require just one of oxygen to saturate them.

Dalton's self-will, or rather obstinacy, that prevented him accepting Gay Lussac's beautiful law, also prevailed in other directions. Thus, he adhered to his own system of atomic symbols (given in the appendix to this memoir), and "steadily persisted in denying the superior precision and expressiveness of the admirable system of chemical formulæ pro-

posed by Berzelius in 1815, and now employed by all European chemists." Dr Wollaston's equivalents received no higher consideration at Dalton's hands.

This disposition to call in question the well-matured opinions of others, and particularly of such nobly efficient, nay, almost unparallelled, workers in the field of chemistry as Gay Lussac and Berzelius, indicated a trait of non-amiability or direct perverseness of feeling in Dalton's psychological nature that is not at all reconcilable with his general deportment and the simplicity of his character. Like many Quakers of the old school, and possibly some of the present, he was self-opinioned beyond the warranty of good manners; but as a man of inductive thought, and constantly engaged in experimental inquiries, his refusal to test for himself what had been advanced by the greatest French chemist of his era seems altogether inexplicable.

Owing to the same cause, call it want of breeding, or a fellside rough independence, he occasionally showed abruptness of manner, and more or less rudeness of speech, even at the meetings of the Literary and Philosophical Society of Manchester, where, as President, it behoved him to practise dignity and forbearance. On one occasion, whilst acting in that capacity, he had to listen to a long-winded paper on some subject foreign to his own studies, and unhesitatingly remarked at the conclusion, "Well, gentleman, I daresay this paper is very interesting to those who take an interest in it."

Dalton did not like to be cross-examined and cross-questioned on scientific subjects, and when

persons indeavoured in this way to get information from him, he used to say, "I have written a book on that subject, and if thou wishest to inform thyself about the matter, thou canst buy my book for 3s. 6d."

In the year 1810 Davy solicited Dalton to offer himself as a candidate for the fellowship of the Royal Society, but he declined, on the ground, it is supposed, of the admission-fee being so heavy. Others have opined that he might have doubts of his election, with Davy so influential in the counsels of the Society, and still opposed to the atomic theory, and moreover, disposed to treat Dalton with a certain amount of *hauteur*, if not professional jealousy. Taking the prevalent opinion, that the fees were a hindrance, the Society, being aware of his humble vocation and means, should have endeavoured to open the way for his admission. Something has been said about precedent and custom; but the laws of the Society were not like those of the Medes and Persians, and it would have been a simple procedure to elect him, and then to pass a resolution exempting him from paying any fees. Surely if any man in England merited public distinction in the first decennial period of this century, it was John Dalton, who had thrown fresh light on the study of meteorology, and proved himself equal to the highest conceptions in science in framing the atomic theory. The leading minds of the metropolis committed an oversight in not enlisting within their ranks the ablest worker in chemistry, by which they incurred the censure of the *savans* of Europe. Manchester showed a higher appreciation of their renowned citizen, and honoured

itself by elevating him to the highest office in the Literary and Philosophical Society.

In November 1810, appeared the second part of the first volume of a "New System of Chemical Philosophy." It was dedicated to Sir H. Davy (then Mr Davy, and Sec. R.S.) and to Dr William Henry, "as a testimony to their distinguished merit in the promotion of chemical science and as an acknowledgment of friendly communications and assistance." To his brother he writes, November 17, "Herewith I send six copies of my 'Chemistry,' Part II., which I have just brought out. The work is not yet finished, but I have no doubt the judicious reader will thank me for the delay, having been spending a great part of my time for the two last years in prosecuting inquiries, the results of which are now published."

The following excerpts from the Preface are interesting :—

When the first part of this work was published, I expected to complete it in little more than a year ; now two years and a half have elapsed, and it is yet in a state of imperfection. The reason of it is the great range of experiments which I have found necessary to take. Having been in my progress so often misled by taking for granted the results of others, I have determined to write as little as possible but what I can attest by my own experience. On this account, the following work will be found to contain more original facts and experiments than any other of its size on the elementary principles of chemistry.

Whatever may be the result of my plan to render the work somewhat like complete by the addition of another volume, I feel great satisfaction in having been enabled thus far to develop *that theory of chemical synthesis, which the longer I contemplate the more I am convinced of its truth.* Enough is already done to enable any one to form a judgment of it. The facts and observations yet in reserve are only of the same kind as those already advanced ; if the latter are not sufficient to

convince, the addition of the former will be but of little avail. In the meantime, those who with me adopt the system will, I have no doubt, find it a very useful guide in the prosecution of all chemical investigations.

Had amity and peace, rather than diplomacy and war, ruled the destinies of Europe at the earlier part of the century, Dalton's claims to the honours conferred by continental *savans* on foreigners of merit would have been recognised on the first propounding of the atomic theory. The French Institute took an early opportunity, namely in 1816, of testifying their high regard for Dalton, by electing him a corresponding member of the Academy of Sciences. This was the first honour awarded to Dalton, and he valued it greatly.

Early in the year 1818 an expedition was fitted out for investigating the Polar regions, and the Royal Society had the power of recommending "a natural philosopher" to go on the expedition. Sir H. Davy, in a very handsome manner, offered the post to Dalton, not omitting to mention the probable remuneration of £500 for the voyage. Dalton was then fifty-two years old, and wisely declined the proposition, on the grounds of not being able to quit the regular habits of a sedentary life for a seafaring one, and that on a voyage of uncertain duration, besides involving a great interruption to his chemical investigations.

All who sought excellence in art and the higher walks of science used to bend their steps to Paris, a city that held out superior advantages to the learned men of Europe, be they naturalists, historians, or physicists. Its libraries, museums, and galleries of

art—its schools of learning, and other admirably organised institutions—its architecture, its gardenesque and floral culture, and not least, its fashionable resorts and gaiety, made the City of the Seine the grandest capital of Europe. To the insular English mind it was, and still is, peculiarly attractive. However he may have been prompted to cross the Straits of Dover, Dalton, accompanied by two intelligent friends, travelled to Paris in 1822, and was richly rewarded for the effort.

Dalton had unfortunately preserved only very brief notes of this interesting journey. The first person upon whom he called was M. Brèguet, the celebrated mechanician, and a member of the Institute, merely with the object of placing in his hands a watch constructed by Brèguet, that required some repairs. When M. Brèguet learned the name of his visitor he welcomed him with the liveliest enthusiasm, and immediately engaged him and his two companions to dinner, where they met M. Arago, M. Fresnel, and other distinguished persons.

"Saturday, July 6th: Received a visit from two Swedish chemists from Abo, in Finland, pupils of Berzelius, Bonsdorf, and Nordenskiold. Visited the Venerable Abbé Gregoire.—7th, Sunday: Attended the service at the British Ambassador's chapel. From one to two hundred present, chiefly English, and more than half ladies. Very genteel and attentive congregation. Good sermon, well calculated for Paris, on the evidences of Christianity. After 4 P.M. took coach with companions for Arcueil, to dine by invitation with the Marquis Laplace and lady. Met Berthollet, Biot and lady,

Fourier, &c., &c. A most agreeable and interesting visit, and a beautiful place.—Monday, 8th July: Walked down to the Arsenal; saw Gay Lussac for half an hour; went to the Jardin du Roi; saw the wild beasts and the anatomical preparations, &c.; took coach home, and then went to the Institute. About one hundred persons present; was introduced by Biot, and placed in the square adjacent to the officers; was announced by Gay Lussac (as president) as a corresponding member (English) present. The sitting was from three to five o'clock.* After my announcement, my two companions were introduced to the same bench during the sitting.—Sunday, 14th: Gay Lussac and Humboldt called and spent an hour on meteorology, &c. Took a coach to Thénard's; breakfast *à la fourchette* with him, family, and Dr Milne-Edwards. Went to the laboratory near M. Biot's, and saw a full set of experiments on the deutoxide of hydrogen, most curious and satisfactory. M. Thénard then went with us through the laboratory; showed us the new theatres for chemistry, physique, &c., and then went to M. Ampère's, who had previously prepared his apparatus for showing the new electro-magnetic phenomena. Saw a set of these experiments, which, with the aid of Dr Edwards, were made intelligible to me.—15th: Took coach to the Arsenal; spent

* Dr Robert Knox was present at the *seance*, and told me that on Mr Dalton's name being announced the president (Gay Lussac) and the other members of the Institute rose from their seats, and bowed to the Manchester philosopher. Such honours, it was remarked at the time, were not offered Napoleon le Grand when he took his seat among the renowned FORTY of France. I remember in the year 1838 seeing Lord Brougham enter the Institute, without, however, eliciting any special mark of attention from its members.

an hour with Gay Lussac in his laboratory; saw his apparatus for specific gravity of steam, vapours, &c. also M. Welters, the improver of chemical distillation, &c. Walked to the Jardin du Roi; *dejeuner à la fourchette* with Monsieur and Madame Cuvier and youngest daughter. M. Cuvier went with us to the museum, and accompanied us for some time, and then left a gentleman to attend us through the museum, being himself engaged, but occasionally meeting us; spent two hours in the museum—the most splendid exhibition of the kind in the universe—it beggars description. Left after two, and took a coach to the Institute; took a cup of coffee, &c., and then entered the library; saw and spoke to MM. Milne-Edwards, Biot, Cuvier, Laplace, Berthollet, Brèguet, &c.; entered the Institute, heard papers by Milne-Edwards, Biot (on "The Zodiac de Denderah"), Fourier, on "The Population of Paris," after which notice was given for strangers to withdraw, when Gay Lussac called to me to stay, if I chose, being a member, which I did. The business was about election of members, and lasted nearly half an hour, after which we broke up. Saw M. Pelletan on coming out, who kindly inquired of me my health, &c.; went with Vanquelin in a coach to dine, when my companions met me; saw M. Payen, a young chemist of promise."

Mr Dockray, one of Dalton's companions, says—"I was particularly struck by observing the impression made on Mr Dalton by the solemnities of Roman Catholic worship, and the evident sincerity of profound devotion which he saw there; and I do not doubt it was to him a page of human nature which till then he had never had an equal opportunity of witnessing.

Second, I think, only to this, for impressiveness of novelty, was the Gallery of the Louvre. I do not doubt but that he felt there was, in the masterpieces of art which he saw there, a new world of interest and wonder on which he would gladly have had the opportunity of longer meditating." Mr Dockray also furnished the following narrative of Dalton's meeting with the philosophers at Arcueil:—

"At four in the afternoon, by a coach, with Dalton to Arcueil, Laplace's country seat, to dine. On alighting, we were conducted through a suite of rooms, where, in succession, dinner, dessert, and coffee tables were set out; and onwards through a large hall, upon a terrace, commanding an extent of gardens and pleasure-grounds. It is in these grounds that are still remaining the principal Roman works near Paris, the vestiges of Julian's residence as Governor of Gaul. Avenues, parterres, and lawns, terraces, and broad gravel-walks, in long vistas of distance, are bounded by woods and by higher grounds. As yet we had seen no one, when part of the company came in view at a distance—a gentleman of advanced years and two young men. Was it possible not to think of the groves of the Academy and the borders of the Ilyssus? We approached this group, when the elderly gentleman took off his hat, and advanced to give his hand to Dalton. It was Berthollet. The two younger were Laplace's son and the astronomer-royal, Arago. Climbing some steps upon a long avenue, we saw, at a distance, Laplace walking uncovered, with Madame Biot on his arm; and Biot, Fourier, and Courtois, father of the Marchioness Laplace. At the front of the house this lady and her grand-daughter met us.

At dinner, Dalton on the right hand of Madame Laplace, and Berthollet on her left, &c. Conversation on the zodiac of Denderah and Egypt (Berthollet and Fourier having been in Egypt with Napoleon), the different eras of Egyptian sculpture, the fact that so little at Rome—of public buildings—is earlier than Augustus, &c. After dinner, again abroad in the beautiful grounds, and along the reservoir and aqueduct of Julian. These ancient works, after falling very much into decay, were restored by Mary de Medicis. Dalton walking with Laplace on one side and Berthollet on the other, I shall never forget."

"The enjoyment and advantage of his stay in Paris," says Dr Henry, "were greatly enhanced by the friendly attentions of Dr Milne-Edwards, who kindly acted as interpreter between him and those of the French *savans* who did not speak English. Dalton was always accustomed to mention Dr Milne-Edwards in terms of grateful regard, and appears to have maintained some intercourse with him by correspondence."

It is said that Mademoiselle Clémentine Cuvier, the only child of the famous Baron George Cuvier, was his *chaperone* to many public places in Paris; and that Dalton regarded her as the most attractive and amiable young creature he had ever seen, and whose early death he sensibly lamented. He never spoke of her without betraying some emotion. One day he said to a friend, "Ah! she was a bonny lass; she treated me like a daughter."

In 1822 some of Dalton's friends proposed him as a candidate for the Fellowship of the Royal Society; he was elected, and paid the usual fees. Nineteen

years previous to his admission to the Royal Society he had been deemed worthy of lecturing to the select audiences of the Royal Institution, London ; and for six years he had enjoyed the honour of being corresponding member of the French Academy of Sciences. Moreover, long before this tardy recognition of his own countrymen, he had received the sincere homage of the most distinguished *savans* in Europe, many of whom had visited or corresponded with him: and his works had claimed the attention and warm approval of the best reviewers of the Continent, and, in short, wherever science was taught and understood.

In the year 1825 King George IV. founded two annual prizes of fifty guineas, to be at the disposal of the Royal Society. Sir H. Davy, in his anniversary discourse of 1826, made known the award of the first prize to Mr John Dalton, "for the development of the chemical theory of definite proportions, usually called the Atomic Theory, and for his various other labours and discoveries in physical and chemical science."

To Mr Dalton belongs the distinction of first unequivocally calling the attention of philosophers to this important subject. Finding that in certain compounds of gaseous bodies the same elements always combined in the same proportions; and that when there was more than one combination the quantity of the elements always had a constant relation, such as 1 to 2 or 1 to 3, or to 4, he explained this fact on the Newtonian doctrine of indivisible atoms, and contended that the relative weight of one atom to that of any other atom being known, its proportions or weight in all its combinations might be ascertained; thus making the statics of chemistry depend upon simple questions in subtraction or multiplication, and enabling the student to deduce an immense number of facts from a few well-authenticated, accurate experimental results. Mr Dalton's permanent reputation will rest upon his having discovered a simple prin-

ciple universally applicable to the facts of chemistry, in fixing the proportions in which bodies combine, and thus laying the foundation for future labours respecting the sublime and transcendental parts of the science of corpuscular motion. His merits in this respect resemble those of Kepler in astronomy. . . . Mr Dalton has been labouring for more than a quarter of a century with the most disinterested views. With the greatest modesty and simplicity of character he has remained in the obscurity of the country, neither asking for approbation, nor offering himself as an object of applause. He is but lately become a fellow of this Society, and the only communication he has given to you is one, compared with his other works, of comparatively small interest; the feeling of the Council on the subject is therefore pure. I am sure he will be gratified by this mark of your approbation of his long and painful labours. It will give a lustre to his character, which it fully deserves; it will anticipate that opinion which posterity must form of his discoveries; and it may make his example more exciting to others in their search after useful knowledge and true glory.

CHAPTER XIV.

"*There is a history in all men's lives,*
Figuring the nature of the times deceas'd;
The which observ'd, a man may prophecy,
With a near aim, of the main chance of things
As yet not come to life."—SHAKESPEARE.

DR DALTON'S HOLIDAYS—MEMBER OF THE FRENCH INSTITUTE—D.C.L—HIS CLAIMS TO A PENSION—OPINIONS OF DRS HENRY AND SEDGWICK ON THE SUBJECT—COURT PRESENTATION—REFUSES KNIGHTHOOD—ILLNESS—VISITS TO EAGLESFIELD—DEATH AND FUNERAL OF DALTON.

WITH the exception of his weekly half-holiday at the bowling-green, Dalton kept all his terms of service most faithfully, and seldom moved out of town till the summer holidays: these he almost invariably spent amid the lakes and mountains of Cumberland and Westmoreland. No change could well be greater than passing from the din and smoke of Manchester to the sylvan banks of Windermere, and the pine-clad slopes of northern England. The air was pure, transparent, and bracing, and his ascent of the highest mountains, by bringing every muscle into operation, naturally called for a larger amount of oxygenation to his system. It was a joyous time to Dalton, who no sooner touched his native heather than he seemed to throw off the incubus of age, and all the depressing influences of urban life. He began

his trips to the Lake Country when his meteorological fervour was at its height, in the third decade of his life, and as this fervour never entirely abated, he went on from year to year for forty years, or as long as his limbs could support him, in his fatiguing explorations. The pleasure of his holidays was enhanced by the opportunity of embracing work with play, and a certain amount of science with large social liberty. How placidly he spent his first day in boating from Low Wood, and viewing Langdale Pikes and the magnificent scenery around Ambleside! The next morning he was early afoot, armed with his barometer and thermometer, and marching with the firm and constant step of a mountain guide, would climb three thousand feet. It was difficult to his companions, indeed to all but the experienced pedestrian, to keep pace with him in his ascent. This fast walking elicited from one of his Quaker friends the remark, "Why, John, what are thy legs made of?" John's legs were so true to their fellside growth, that the civic restraint of months together seemed in nowise to impair their capacity for the greatest demands of pedestrianship.

After his return in an evening from measuring the height of Helvellyn—his favourite mountain for observation—how he enjoyed the roadside hostelry—its snug parlour, its neat service, its savoury ham, and the fresh trout from the "beck"—its oat-cakes, and cream cheese, followed by draughts of good home-brewed ale. After a bountiful supply of the inner man, he would take his seat on the rude bench outside the trellised porch of the "White Swan Inn" and smoke his "Virginian," whilst he looked with placid admiration on the green meadows and purling

waters backed by wooded knolls, and these again overtopped by higher and higher ranges, presenting endless variety of form and colour, either sparkling in light, or dimly shadowed by passing clouds, but ever suggestive and beautiful to the æsthetic mind. On one of these excursions, in 1812, he made the acquaintance of Mr Jonathan Otley, who knew every nook and corner of the Lake District, and who wrote by far the best work on the subject—"A Descriptive Guide to the English Lakes and Adjacent Mountains," —a book now held old-fashioned,* but the basis of all that has been since published in tourist form. Mr Otley has given an interesting narrative of his excursions with Dalton, from which it would appear that the philosopher embraced every opportunity of studying the constitution of the atmosphere, and the transition from cloud to sunshine and from sunshine to shadow, in "those loftier regions." The heights of the mountains, and their marked geological features; the dew point; the quantity and density of vapour; the fall of rain; the direction of the winds, and, in short, all the natural phenomena presenting themselves to the experienced observer, were duly noted and commented upon. He was not easily deterred by the threatening aspects of the weather, but seemed satisfied with the prospects of the day if he could only see, as he used to say, as much blue sky as would make a pair of breeches.

Dalton's party was sometimes too large to be ac-

* To those who really wish to *know* the Lake District as it ought to be known, let me commend the beautifully-written volume of my clever friend Mrs E. Lynn Linton, entitled, "The Lake Country," neatly illustrated by her husband.

commodated under one roof, and the search for night-shelter in the farm-houses of these outlying districts often caused much diversion. There were no grand hotels in those days, and the shifts to which innkeepers and their daughters were placed, rather than lose a customer, may be instanced from Dalton's experience. When describing one of his many trips to the Lake District, Dalton was asked by a young lady friend if he had seen the celebrated beauty, Mary of Buttermere,* the daughter of the landlord of the inn in that place. "No," said he, "but I have slept in her bed; for one night I arrived wet and tired at Buttermere to find the inn full; but by dint of persuasion a room was found for me, and Mary got out of her bed, and I got in, and right warm it was, I can tell thee."

The death of Sir H. Davy caused a vacant seat in the French Academy of Sciences, and Dalton who had for fourteen years enjoyed the honour of being a corresponding member, was in 1830, raised to the rank of one of its eight foreign associates, the highest compliment in its power to bestow, and universally regarded as the crowning distinction in European

* Mary of Buttermere, the theme of many a fanciful story and rural ditty, and the heroine of a three-volumed novel, gave a personal colouring to the picturesque and romantic scenery of the Lakes in days gone by. Her marriage to Hatfield the forger was sad enough; in her second espousals she was fortunate in having a worthy yeoman, to whom she bore a family of handsome children, her daughters being as pretty as she was in her youth. I made her acquaintance under painful circumstances. She had then passed the climacteric of age, and the existence of a cancerous breast, in the removal of which I assisted, had considerably affected her looks; yet through these lines and sallow colouring that organic disease had made so striking, the lineaments of the beautiful in form still prevailed. She died at the How, near Caldbeck, and, as far as I can recollect, in the year 1836.

Science. In the words of Baron Cuvier in his *eloge* on Dr Joseph Priestley, "L'Académie de Paris lui accorda un prix non moins noble et plus difficile encore à obtenir, parcequ'il est plus rare, l'une de ces huit places d'associés étrangers, auxquelles tous les savans de l'Europe concourent, et dont la liste, commençant par les noms de Newton, de Leibnitz, et de Pierre le Grand, n'a dégenéré dans aucun temps de ce premier éclat."

John Dalton placed a proper estimate on the honours and distinctions conferred upon him by the universities and learned societies of his own country, and that estimate was, if possible, enhanced by the unsolicited and gratifying acknowledgments paid to his scientific status by several of the more renowned continental academies; *e.g.*, Berlin, Munich, and Moscow. His highest honour, that marked his supremacy in the world of thought, was the Foreign Associateship of the Academy of Sciences, for there he ranked among the eight *élite* of Europe. It may be remarked parenthetically, as a circumstance highly flattering to our national genius, that of the eight chairs of honour offered to the competition of the world at large by the French Institute, no less than four of these were occupied at one time by Englishmen.

With all his quiet reserve and reticence, it was manifest to the Johns family that Dalton liked the company of men of distinction, and especially those devoted to science, and was not a little proud of the numerous visitors who found their way to Manchester on his account. The presence of such men as Professor Thomson the chemist, Sir John Leslie, Dr Chalmers,

and Sir D. Brewster, of world-wide fame, from the sister kingdom, could not fail to be gratifying to his *amour-propre;* and this pleasure was enhanced on the appearance in his humble lodgings or laboratory of eminent *savans* from the Continent. Owing to his staid demeanour, and plain, dry mode of accosting others, that occasionally implied indifference, or even rusticity and rudeness, his reception of foreigners was not always what it should have been, much less was it *en accord* with their gentility and politeness. A great deal depended on the humour which prevailed with the meditative philosopher. He could be kind and affable in manner, and occasionally make his reception of strangers agreeable, and their introduction to the Johns family worthy of the jocular strain of M. Biot; at other times he seemed to forget the ordinary courtesies of life, as is shown in the following paragraph.

A few intimate friends were drinking an early tea with Dalton at the Rev. Mr Johns' when some distinguished French *savans,* members of the French Academy, were announced as having come to see the great chemist. Dalton, by nature a silent and reserved man, and disliking in any way to be called out, was, after the introduction, barely civil to the talkative foreign gentlemen, and scarcely spoke a word during the interview. When tea was over, he quietly got up from table, and called to the old servant for his lantern, and silently withdrew, walking across, as was his wont, to his laboratory at the Society's rooms. Mr Johns then asked one of the French Academicians what he thought of the great philosopher. "Ah!" he replied, "*Monsieur Dalton a une simplicité admirable.*"

Though not one of the original promoters of the British Association for the Advancement of Science, he was present at its first meeting, held in York in 1831, and as long as his health permitted, continued to take great interest in its proceedings. On the occasion of the second meeting, at Oxford in 1832, the honorary degree of D.C.L. was conferred upon him and three most worthy compeers, Dr Michael Faraday, Sir David Brewster, and Robert Brown. Dalton was apparently proud of his Doctor's red gown, as he perambulated the halls and gardens of Oxford, and cared not to be quizzed about his scarlet robing, inasmuch as its colour differed not from the green foliage of the trees shadowing him and his companions on the banks of the Isis.

To the eminent Mr Charles Babbage is due the credit of having been the first person to moot the desirability of an annual pension being granted to Dr Dalton, in a letter he addressed to Dr Henry, senior, of Manchester, as early as the year 1829. He also laboured zealously at headquarters to obtain the acquiescence of the Government to his proposal, and found no small support to his application in the able statement furnished by Dr Henry; portions of which deserve quoting, not less for the noble sentiments it contains than the just estimate conveyed to us of the character of Dr Dalton :—

Mr Dalton never had, nor was ever given to expect, any reward or encouragement whatsoever from Government, and having been in habits of unreserved communication with him for more than thirty years, I can safely aver that it never occurred to him to seek it. He has looked for his reward to purer and nobler sources; to a love of science for its own sake; to the tranquil enjoyments derived from the exercise of his

faculties in the way most congenial to his tastes and habits, and to the occasional gleams of more lively pleasure, which have broken in upon his mind, when led to the discovery of new facts, or the deduction of important general laws. By the moderation of his wants and the habitual control over his desires, he has been preserved from worldly disappointments; and by the calmness of his temper and the liberality of his views, he has escaped those irritations that too often beset men who are over-anxious for the possession of fame, and are impatient to grasp prematurely the benefits of its award. For a long series of years he bore neglect, and sometimes even contumely, with the dignity of a philosopher, who though free from anything like vanity or arrogance, yet knows his own strength, estimates correctly his own achievements, and leaves to the world, generally although sometimes slowly just, the final adjudication of his fame. Among the numerous honours that have since been conferred on him by the best judges of scientific merit in this and other countries, not one has been sought by him. They have been, without exception, spontaneous offerings, prompted by a warm and generous approbation of his philosophical labours, and by the desire to cheer him onward in the same prosperous career. Deeply as he has felt these distinctions, they have never carried him beyond that sober and well-regulated love of reputation, which exists in the purest minds, and is one of the noblest principles of action.

In perfect consistency with Mr Dalton's intellectual qualities are the moral features of his character, the disinterestedness, the independence, the truthfulness, and the integrity which through life have uniformly marked his conduct towards others. Nor is it on the atomic theory only that his reputation must rest. It has a broader basis in his beautiful and successful investigations into the subject of heat; into the relations of air and moisture to each other; and into a variety of other topics intimately connected with the stability and advancement of chemical philosophy. I therefore agree with you that Mr Dalton has strong claims upon the national respect and gratitude, and contend for his title to reward, even though he may not have accomplished anything bearing strictly upon the improvement of those arts and manufactures which are the

chief sources of our national wealth. For, let it be remembered, that every new truth in science has a natural and necessary tendency to furnish, if not immediately yet at some future time, valuable rules in art.

. . . .

It would surely be unworthy of a great nation to be governed in rewarding or encouraging genius by the narrow principle of a strict barter of advantages. With respect to great poets and great historians, no such parsimony has ever been exercised. They have been rewarded, and justly, for the contributions they have cast into the treasury of our purely intellectual wealth. And do not justice and policy equally demand that a philosopher of the very highest rank, one who has limited his worldly views to little more than the supply of his natural wants, and has devoted for more than forty years the energies of his powerful mind to enlarging the dimensions of science, should be cherished and honoured by that country which receives by reflection the lustre of his well-earned fame? It is most desirable, then, that the British Government, by extending its justice to another not less illustrious, should be spared the deep reproach, which otherwise assuredly awaits it, of having treated with coldness and neglect one who has contributed so much to raise his country high among intellectual nations, and to exalt the philosophical glory of the age.

The admirable letter just quoted was brought under the notice of Earl Grey's Government, and Lord Brougham professed himself "very anxious to obtain some provision for Dalton, but that it was attended with great difficulty." * After much writing, and protocoling and canvassing of the parlia-

* Lord Brougham could see no difficulty in appointing his brother a Master of Chancery, when he himself had already prepared a bill to extinguish the office, and with the view of compensating the retiring masters with the pretty sum of £2200 a year for a few months of the most trifling service. Talleyrand, or some other equally wide-awake Frenchman, who had carefully studied our institutions, maintained that England was the very paradise for priests. Had he known of the

mentary economists, it was not till June 1833 that anything got done. The mountain had been in labour for three or four years, and then crept out the little mouse in the shape of a paltry sum of £150 a year, to be bestowed by the richest nation on earth on the most gifted of persons, and the chief scientific leader of his epoch.

It was deemed advisable to announce the fact of the pension to Dalton at the meeting of the British Association held at Cambridge in 1833; and Lord Monteagle, just before the meeting, requested Professor Sedgwick, the President, to allude to it in his introductory address. The words in which the learned professor, without notes or preparation, offered his "fervent heartfelt homage to the genius of Dalton," are marked by a rare eloquence, worthy of the highest master of the art. They were as follows:—

They had all read a highly poetical passage of a sacred prophet, expressed in language, to the beauty of which he had never before been so forcibly awakened as at that moment—"How beautiful upon the mountains are the feet of him that bringeth good tidings." If he might dare to make an adaptation of words so sacred, he would say that he felt himself in the position here contemplated—of one who had the delightful privilege of announcing good tidings, for it was his happiness to proclaim to them what would rejoice the heart of every true lover of science. There was a philosopher sitting among them, whose hair was blanched by time, whose features had some of the lines of approaching old age, but possessing an intellect still in

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above instance of naked nepotism, and lawyer fattening lawyer, he would have found two parties in the English paradise; and that a fourth-rate barrister, almost briefless, was estimated in the year of grace 1833, and a reformed Parliament in England (in the proportion of £2200 to £150), at *fourteen times the value* of the greatest man of science born to England since the days of Newton.

its healthiest vigour—a man whose whole life had been devoted to the cause of truth ; he meant his valuable friend Dr Dalton. Without any powerful apparatus for making philosophical experiments—with an apparatus, indeed, many of them might almost think contemptible—and with very limited external means for employing his great natural powers, he had gone straightforward in his distinguished course, and obtained for himself, in those branches of knowledge which he had cultivated, a name not perhaps equalled by that of any other living philosopher of the world. From the hour he came from his mother's womb, the God of Nature had laid His hand upon his head, and had ordained him for the ministration of high philosophy. But his natural talents, great as they were, and his almost intuitive skill in tracing the relations of material phenomena, would have been of comparatively little value to himself and to society, had there not been superadded to them a beautiful moral simplicity and singleness of heart, which made him go on steadily in the way he saw before him, without turning to the right hand or to the left, and taught him to do homage to no authority before that of truth. Fixing his eye on the highest views of science, his experiments had never an insulated character, but were always made as contributions towards some important end—were among the steps towards some lofty generalisation. And with a most happy prescience of the points towards which the rays of scattered experiments were converging, he had more than once seen light, while to other eyes all was yet in darkness ; out of seeming confusion had elicited order, and had thus reached the high distinction of becoming one of the greatest legislators of chemical science.

While travelling among the highest mountains of Cumberland, and scarifying the face of Nature with his hammer, he (the President) had first the happiness of being admitted to the friendship of this great and good man, who was at that time employed, day by day, in soaring among the heavens, and bringing the turbulent elements themselves under his intellectual domination. He would not have dwelt so long on these topics, had it not been his delightful privilege to announce for the first time (on the authority of a minister of the Crown who sat near him), that his Majesty King William the Fourth, wishing to

manifest his attachment to science, and his regard for a character like that of Dalton, had graciously conferred on him, out of the funds of the civil list, a substantial mark of his royal favour.

The announcement was received with long-continued applause.

Such a eulogium as Professor Sedgwick pronounced in the Senate House of Cambridge, to a crowded audience of scientific men gathered from all corners of the civilised globe, could not fail to reach the inmost heart of Dalton, who, if his memory of the past served him in that hour of trial and triumph, would probably recall his humble parentage and the prospects of his youth offering nothing better than the weaver's loom or the spade and the plough. As he sat, the observed of all observers, in the midst of as distinguished an assembly of *savans* as the world could present, he could not fail to realise the sentiment so beautifully expressed by the illustrious Sedgwick, that "the God of Nature had laid His hand upon his head, and had ordained him for the ministration of high philosophy."

Manchester, true to her commercial instincts of rewarding merit where merit is due, and wishing to do honour to her great chief in science, determined on having a full-sized statue of Dr Dalton sculptured by Sir Francis Chantrey. Accordingly Dr Dalton went to London in May 1834, and gave Chantrey the necessary sittings. The Chantrey statue of Dalton is now in the entrance-hall of the Manchester Royal Institution; and a copy of it in bronze is placed in the front of the Royal Infirmary, where are also statues of the Duke of Wellingon, Sir R. Peel, and James Watt.

On the year following the "royal bounty" of £150

a year, some of Dalton's more ardent friends were of opinion that he should appear at the Court of William IV. It might have been, indeed was, supposed by many persons that his retired habits, grave demeanour, and Quakerish nature would be directly opposed to a courtly ceremonial under any circumstances. And so, probably, he would have thought and determined in earlier life; but he was then in his sixty-eighth year, when the reputed glitter and pageantry of courts may have revived in him the curiosity of juvenility: baubles, sometimes becoming a source of attraction to men when verging on the "lean and slippered pantaloon" of age. Mr Babbage has given a lively account of his efforts to indoctrinate Dalton in the ways of the Court, actually rehearsing for his benefit the mode of presentation to royalty. The difficulty of a court dress was readily obviated by Dalton appearing in the scarlet robes* of an Oxonian Doctor of Laws; and this colour, it need hardly be noted, did not disturb his drab proclivities in the slightest degree; nay, accorded so entirely with them that he felt quite at home, and totally unaware of the various comments made upon his figure and habiliments—Quaker in his nether gar-

* He had evidently gone to London unprepared beyond a good suit of clothes, as in his account-book there is the entry of "a guinea paid for loan of doctor's gown"—a circumstance that may have influenced his observations of the tailors' shops on his way to a house in the city, where some friends of both sexes were waiting to hear his account of the Court presentation. "Well, John, thou wilt have much to tell us," said one of them. "Oh, I don't know," replied Dalton, "but I have been struck on my way hither with the appropriateness of a name to the vocation of a man, having seen on the signboard of a tailor, Thomas Bumfit, Breeches Maker."

ments, with Church and State colouring in its glaring form enveloping his person.

Dr Dalton's costume, as he appeared at Court, naturally attracted attention from its novelty, and whispers were heard of "who can this be?" Some looked upon him as a provincial mayor coming up to be knighted; others thought him a man of mark; and an officer was heard saying, "Who the devil is that fellow whom the King keeps talking to so long?" Mr Babbage, the only person who knew Dalton, enjoyed the fun arising out of this curiosity, and joked the bishops standing near, by saying that he had a Quaker by his side—a fact calculated to call forth the old cry of the "Church in danger." It is said that Lord Brougham promised to enlighten the King as to Dalton's character, so that he might say something to the philosopher that might please Manchester. Another version holds good, that Dalton's figure and dress caught the King's eye, and he quickly asked, "Who is this?" "This, please your Majesty," said the official, as Dalton awkwardly passed up, "is the great Manchester philosopher, Dr Dalton." "Oh," said the King, and then turning to Dalton, "Well, how are you getting on at Manchester; all quiet I suppose?" This remark of Majesty sprang from the unpleasant recollection of the Peterloo riots of 1819, and the reputed Radicalism of Manchester. This, and one or two common-place remarks, would appear to have been pretty nearly all the notice that royalty took of a man whose name will be known to the nations of the earth when that of William the Fourth of England is buried in well-merited oblivion.

Not content with having persuaded him to go to Court, some of his over-zealous friends wished to see him knighted. Dr Dalton being made aware of their intention, felt not a moment's hesitation in refusing to accede to their proposal, and along with his affirmation to that effect, declared he would not bend his knee to any man on earth, neither king nor potentate, for any earthly honours that might be conferred upon him. Moreover, the privilege of adding SIR to his name could not be viewed by Dalton as any honour at all, when it was so freely distributed upon every gold-stick, and fiddle-stick, and groom-in-waiting about the Court. His views probably accorded with those of a distinguished admiral* mentioned below; at any rate he did not wish to be classified with the rank and file of flunkyism.

In describing his summer holidays among the mountains of Cumberland, I purposely abstained from speaking of his visits to his home district of Eaglesfield till a more appropriate opportunity. On his way to the haunts of his youth, he generally stopped

* A well-known admiral, who in former times had served with Prince William Henry (Duke of Clarence), was, after the accession of that prince to the throne, presented at Court. The admiral had distinguished himself in various ways, but especially in the survey of the Mediterranean Sea, his chart and surveys being then, as now, the best book of all navigators in that stormy region. His Majesty (William IV.) at once recognised his old shipmate, and said, "You have done good service to navigation, we must bestow some honour upon you. What do you say to knighthood?" The admiral (then a captain) said, "I esteem it a much higher honour to be a captain in your Majesty's service than to be a knight." The King said, "Well, but I knighted your friend —— the other day." The answer was, "Your Majesty served him right!"

a night at the Globe Hotel, Cockermouth, where he received some of his friends to supper. Next morning he was early astir, as if impatient to reach his old home, and to shake hands with the "weel-kent friends" of the hamlet. In his manners and dialect he was as much a Cumbrian after forty-five years' residence in Manchester, as he was on the day he tramped from Eaglesfield to Kendal in his sixteenth year—a raw lad, whose survey of the world had been confined to the borough of Cockermouth. He talked about the weather and the crops, and how things were done in his boyhood, or he accosted old farming friends by saying, "What, ye'll be thrang wi' yer hay?" and on being invited within doors, sat down, lighted his pipe, and then had what Cumbrians call a "real gude crack" about old times. It was a delight to Dalton to meet his early associate William Alderson, and Joseph Dickinson and others, to talk over the days o' auld langsyne at a cottage fireside in Eaglesfield, where old Alderson, not seeing the utility or elegance of a fender, would use his clogs to kick any stray cinders behind the grate.

Among those whom Dalton regularly visited was his esteemed friend John Wilson Fletcher of Tarn Bank, near Cockermouth. After Dalton's introduction to the Court, Mr Fletcher asked him how he got on with William IV. and the grand folk at St James's, and what passed between him and the King. Dalton told him that the King said, "Ah! Dr Dalton, how are you getting on at Manchester?" to which he replied, "Well, I don't know; just middlin', I think." Mr Fletcher, after a hearty laugh at John's simplicity of speech, said, "Why, John, thou hardly showed

Court manners in addressing the King in such common parlance." John Dalton's remark upon this comment of his friend far surpassed his reply made to the King; it was given in broad Cumbrian dialect, "Mebby sae, but what can yan say to see like fowk?"

On one of his visits to his old friends in Cumberland, Dalton attended the annual examination of the children at the Friends' School, Brookfield, near Wigton. When the examination in grammar was proceeding (Lindley Murray being the text-book of the school), Mr Cook, the head-master, asked the Doctor if he would like to put any questions to the children. "No," said he; "for I consider that of al the contrivances ever invented by human ingenuity to puzzle the brains of the young, Lindley Murray's grammar to be the worst."

This sentiment, it need hardly be added, gave the Doctor great popularity among the Brookfield lads, who on resorting to the playground gave him three hearty cheers.

An anecdote may be related which shows the trust he put in arduous industry, compared with the exercise of what the world calls genius. Entertaining Jonathan —— and his son to supper at the Globe Hotel, the conversation fell on education, and this led Dalton to inquire into the studies and progress of his young friend; he then said to him, "Thou seems to have better talents than I possessed at thy age; but thou may want the thing that I had a good share of—perseverance." The doctrine that greatness in every walk of life is only attained by dogged perseverance, he was accustomed to maintain at all times and seasons.

Thus he wrote: "If I have succeeded better than many who surround me, it has been chiefly—nay, I may say, almost solely—from unwearied assiduity. It is not so much from any superior genius that one man possesses over another, but more from attention to study, and perseverance in the objects before them, that some men rise to greater eminence than others." Like Sir Isaac Newton, Dalton did not believe in such a thing as genius; and though it be too much to say that they were altogether right in their estimation of the operations of the human understanding under varied conditions of life, history and biography offer large evidence in their favour. Little has been done in the world without painstaking observation and industry; on the other hand, a true inspiration has often given point and character to a subject which hard-earned labour had failed to elucidate or comprehend.

In Dalton's instance, perseverance made him the best scholar in Pardshaw School; perseverance supported him in making 200,000 meteorological observations; perseverance from his first introduction to chemistry enabled him to develop the atomic theory; and the same perseverance gained him one of the highest seats in the French Institute—the crowning distinction of European eminence.

In the autumn of the year 1834, on the occasion of the meeting of the British Association at Edinburgh, the Senate of the Northern University conferred upon Dr Dalton the degree of LL.D.

In December of the same year Jonathan Dalton died, leaving all his real and personal estate to his brother, Dr John Dalton. With this accession to his

own hoardings, and the pension of £150 a-year, he was well-to-do in the world, and considered himself rich enough to buy a full set of silver spoons for dinner, dessert, and tea service. In 1836 the royal bounty was augmented to £300 a-year.

The long-continued good health that Dalton enjoyed was suddenly broken in upon by a paralytic seizure on the 18th April 1837. He had on the previous evening had a long and warm discussion on chemical notation and symbols, and had evidently got much excited. Early in June he had sufficiently recovered to send to the Royal Society his "Sequel to an Essay on the Constitution of the Atmosphere," that was published in his Philosophical Transactions for 1837.

From a memorandum of Miss Johns' (December 9, 1840) it would appear that Dalton was making notes of his life. On the same evening he spoke of his election to the Academy of Sciences, and of Laplace being the greatest man of his age, nor did he forget the extraordinary powers of Cuvier. Of one of the Frenchmen who fell under consideration, Dalton said, "Aye, he was a nonentity, as I am now." "No, no," said Miss Johns to him, "you are not a nonentity yet;" but still he seemed to feel a difference from what he had been. After this period Dalton's memory was hardly trustworthy, and his persistence in work tended materially to make his deteriorated brain worse and worse.

In his latter days, when possessed of ample means, John Dalton felt anxious to distribute his property among his blood relations and others who had befriended his early years, and the following letter indi

cates a wish to know the relations of the Robinsons of Eaglesfield to his ancestral tree :—

MANCHESTER, *19th of 11th month*, 1841.

DEAR FRIEND, JOHN ROBINSON.—I left Eaglesfield when I was very young (about 15), and never returned but a very few days; my sojourning was 12 years at Kendal, and upwards of 48 at Manchester. Of course I could not be apprised of my relations ; but now when one has time to reflect on the past, we are engaged to look back at our ancestors.

Thomas Fearon, my great grandfather, and Mary Gill of Eaglesfield, were married at Pardsey Cragg (Pardshaw Hall), in 1688. 35 witnesses.

Jonathan Dalton, shoemaker [my grandfather], and Abigail Fearon of Eaglesfield, were married at Pardsey Cragg (Pardshaw Hall), in 1712. 19 witnesses.

Joseph Dalton of Eaglesfield [my father], and Deborah Greenup of Caldbeck, were married at Cockermouth in 1755. 37 witnesses.

John Robinson was among the witnesses of Thomas Fearon and Mary Gill. *Samuel Robinson*, *Joseph Robinson*, *Matthew Robinson*, *John Robinson*, were amongst the witnesses of my *grandfather's* marriage.

Betty Robinson, *John Robinson*, *Elihu Robinson*, *John Robinson*, were among the Robinsons in my *father's* marriage ; taking them in succession.

I would like to know whether *Samuel Robinson*, who was joint co-partner for a deed of Mary Fearon, youngest sister of Abigail Fearon, thou must know, I conceive, whether one of *thy* relations, or *Elihu's* relation. I used to call Elihu my *cousin*, but *he* seemed not to be near of kin to me. Thou must know, I guess, whether *Samuel Robinson* was thy *grandfather*, or not.

When I left Eaglesfield there were John Robinson, the father, John Robinson (of fauld), son, I believe, of old Betty Robinson (widow), and her two or three daughters, Friends ; *old* Isaac Robinson, and *young* Isaac Robinson (of fauld) ; and Elihu Robinson ; and not to forget Dinah Robinson ; she died some time before I left.

Samuel Robinson and John Gill were appointed trustees to my great grandfather, Thomas Fearon. Thomas Fearon calls him, in his last will, my "brother Samuel Robinson;" is there any name *Samuel* of your family? Thy assured friend—JOHN DALTON.

I do not forget your kind entertainment of the bidders to my estate.

[This postscript refers to the sale of his property, which he wished converted into money, to enable him to distribute his effects equally among his relatives and friends.]

The British Association met in 1842 at Manchester. Dalton's infirm state of health rendered it impossible for him to fill the office of President, for which he was designated; so he acted as one of the Vice-Presidents. Lord Francis Egerton filled the chair, and made the following appropriate remarks:—

"Manchester has, in my opinion, a claim of equal interest as the birthplace,* and still the residence and scene of the labours of one whose name is uttered with respect wherever science is cultivated, who is here to-night to enjoy the honours due to a long career of persevering devotion to knowledge, and to receive, if he will condescend to do so, from myself, the expression of my own deep personal regret, that increase of years, which to him up to this hour has been but increase of wisdom, should have rendered him, in respect of mere bodily strength, unable to fill on this occasion an office which, in his case, would have received more honour than it could confer. I do regret that any cause should have prevented the present meeting, in his native town, from being associated with the name of Dalton as its president. The council well know my views and wishes in this matter, and that could my services have been available, I

* Owing to Dalton's long residence of fifty years, Manchester in the eyes of a vast majority of people was considered his birthplace.

would gladly have served as a doorkeeper in any house where the father of science in Manchester was enjoying his just pre-eminence."

With his increasing years came increased debility, so that he required the constant attention of an attached servant. On the 20th May 1844, he had a slight fit; and on the 27th July of the same year, after an effort to rise, he had fallen backwards from his bed, and was found with his head on the floor quite lifeless.

His body was examined by Messrs Ransome and Wilson, who found "in the anterior portion of the middle lobe of the brain, on the left side, above the filsure of Sylvius, a firm, thick sac containing the *débris* of an old coagulum, and softening of the brain around it. The weight of the brain and membranes was about 3¼ lbs." *

There was nothing in the humours of the eye (as already stated in the chapter on Colour-blindness) to account for his colour-blindness. A phrenologist present at the *post-mortem* examination pointed out what he considered a deficient development of the convolutions of the anterior lobes resting on the frontal portion of the orbitar plates, the phrenological site of the "organ of colour."

No sooner had the death of Dr Dalton been announced, than a universal feeling arose in the city of Manchester, from the ruling powers to the humblest citizen, to pay all honour to the memory of the

* It is to be regretted that Mr Ransome had not been more definite as to the weights he used, and whether it was the brain proper or the encephalon he weighed, so that some comparisons might have been instituted between Dalton's brain and those of Cuvier, Blumenbach, Abercrombie, and others.

deceased philosopher. A public funeral was resolved upon, and in imitation of the honours paid to the great in State and Church, the coffin containing his remains were placed in the Town Hall, in a darkened apartment, hung with back drapery, and illuminated by artificial light. In one day upwards of 40,000 persons passed through the Town Hall to gratify their curiosity * by a sight of a "beautiful mahogany coffin" containing the remains of the deceased. The public funeral took place on Monday, August 12, and in point of numbers of persons present, and private carriages—nearly one hundred—as well as in the display of all the paraphernalia of woe, such a funeral was probably never witnessed in provincial England. Four hundred of the police were on duty, each with an emblem of mourning, and the funeral train was nearly a mile in length. Almost every public body in the towns of Manchester and Salford were represented in the procession. The shops and warehouses were closed; the windows were lined with spectators, as well as the roofs of the houses. The burial took place in the Ardwick Cemetery. The grave is enclosed and covered by a massive block of polished red granite, inscribed JOHN DALTON, and in smaller letters the dates of his birth and death.

At the sale of Dr Dalton's furniture and effects, in October 1844, seven hundred volumes of books were offered for sale, some of them of considerable value. He died possessed of about £8000 personality, besides

* No wonder the Society of Friends, whose mode of interment is so simple, yet so solemn and impressive, entered their protest against the "lying in state" of one of their members, as they have uniformly borne "a testimony against all parade and show on such occasions, and against all external emblems of mourning."

the realty, which consisted of six houses, bequeathed to Mr Alderman Nield and Mr Peter Clare, two of his oldest friends. He made his will on December 22, 1841, and a codicil in June 1843. With the exception of £500 to the Quaker's school at Ackworth, Yorkshire, and £300 to a similar school at Brookfield, and £50 to the Eaglesfield and Blind Bothell School at Paddle, Cumberland, he distributed his money pretty equally among his relatives and friends.

A meeting was held on January 26, 1853, in the Town Hall, Manchester, for promoting a testimonial to the memory of John Dalton; a committee was appointed to collect subscriptions for the erection of a monument over his grave in the Ardwick Cemetery, and of a statue in front of the Manchester Royal Infirmary; and also to found one or more scholarships for the best original investigation in Chemistry, to be prosecuted in the laboratory of the Owens' College. A sum of upwards of £4000 was devoted to this latter object, and a more fitting testimonial could not have been proposed. "The establishment in England," sagaciously observes Professor Roscoe, "of a scholarship for original research, was, twenty-one years ago, a circumstance without a parallel; but in spite of the novelty of the experiment, time has fully proved the wisdom of the course which its originators adopted, and already a considerable number of men have had the Dalton Scholarship awarded to them for original work of a more or less important character, and are now holding high and responsible positions in scientific, manufacturing, and official life."

CHAPTER XV.

"*Truth is the daughter of Time, and not of Authority.*"

—LORD BACON.

BONAPARTE'S LOVE OF SCIENCE—OPINIONS OF THOMSON, WOLLASTON, HERSCHEL, GRAHAM, BERZELIUS, FARADAY, LIEBIG, ROSCOE, CANNIZZARO, TYNDALL, DUMAS, AND WURTZ ON THE ATOMIC THEORY.

GENERAL NAPOLEON BONAPARTE, in his expedition to Egypt, was accompanied by naturalists, historians, and others eminent in art and science, selected for special services in exploring the land of the Pharaohs. After the decisive battle of the Pyramids, Bonaparte, stationed at Cairo, was one day riding through the Uzbekéëh gardens with M. Monge,* one of the Scientific Institute the General had founded in Egypt, whom he thus addressed :—"I find myself here the conqueror of Egypt, marching in the footsteps of Alexander the Great, but I should have greatly preferred following those of Sir Isaac Newton." M. Monge remarked that Newton had exhausted the field of discovery in physics, leaving nothing to those who might follow him. "By no means," was Bonaparte's reply, "Newton dealt with masses of matter, and with their movements; I

* This was Gaspard Monge, who founded the Normal and Polytechnic Schools of Paris, and proved himself equal to the organisation of numerous schemes for the benefit of the French Empire.

should have sought in the atoms for the laws by which worlds have been constructed." What a testimony to the genius of the young Corsican, who, with a full appreciation of the light that Newton's mind had revealed of the laws of gravitation affecting the great orbs, was incited by motives of ambition to soar for the light that should disclose the infinitesimal small in the worlds of atoms. Whilst the bright Eastern sun was warming the lofty inspirations of the soldier of France towards scientific discovery, the son of a poor weaver, a humble schoolmaster and man of peace, in a dingy room of smoky Manchester, was preparing his balances and crude apparatus for the solution of that great problem in the physics of chemistry that Bonaparte longed to be master of.

Though the laws of definite, reciprocal, and multiple proportions remain in their integrity as laid down by Dalton, it must not be supposed that all his experiments, much less his combining weights of elements and calculations, are to be viewed as faultless. Thus, more accurate experimenting than his has proved that certain atoms are a little heavier, and others a little lighter than he believed ; and the work of perfecting the observations of chemists is constantly going on, aided very materially by improved instruments and methods of operating. Rarely can the claim be made for approximative perfection, even in the arts guided by the best mechanical skill. In science, it need not be said, there are greater difficulties to contend with, inasmuch as science has to do with phenomena more subtle in nature, more diversified in relations, than mere technological plans and arrangements. Hence it may be inferred that the

exposition, if not a portion of the doctrines promulgated by Dalton, has undergone certain modifications, not affecting that part of his views which ascribed the union of indestructible atoms to chemical affinity, but rather the accuracy of his balance and the relative weights of the substances he treated. This is of minor import compared with the great strides he made upon the ancient atomists, and the more modern Cartesian philosophers, who could only see the irregular and fortuitous in the arrangement of atoms, and not a constant and methodical action affecting all molecular arrangements.

Dalton met with opponents in his own day, and there are still some to be found who object to his theory; but hitherto they have not shown any inconsistency in the atomic theory, nor in the conclusions to which it leads. As Professor Williamson, in his able address as President of the British Association at Bradford in 1873, observed on this subject, that no philosopher had been able to explain "the facts of chemistry on the assumption that there are no atoms, but that matter is infinitely divisible." Nay more, that "when they interpret their analyses, these chemists allow themselves neither more nor less latitude than the atomic theory allows: in fact, they are unconsciously guided by it." No doubt it is by examining the combining proportions of atoms that we get clear ideas of the constitution of matter—that great desideratum in the mental vision of Napoleon le Grand.

The test of a good hypothesis is its conformity with observed facts, and Dalton's theory is thoroughly reconcilable with this view. The most satisfactory

theories often involve suppositions of an irreconcilable character. Thus, how difficult it is to frame one's notions of the force of gravity acting instantaneously, between the most distant parts of the planetary system ; or that a touch of electricity should be made to pass along a wire of 23,000 miles in length in a single second ; or that a ray of violet light should consist of 700 billions of vibrations in each second : yet these statements, however extraordinary in character, are essential to enable us to explain the phenomena observed by the physicist.

The Abbé Boscovich said that we are to understand by hypotheses "not fictions altogether arbitrary, but suppositions conformable to experience or analogy." Newton's motto of "*Hypotheses non fingo*," heralding his "Principia," was not only called in question, but treated as somewhat ironical ; so much so, that Liebnitz and other philosophers on the Continent repelled the Newtonian tenet, and animadverted strongly on his re-introducing part of his occult chemistry into the science of facts.

In a previous chapter of this memoir, circumstances of historical note and proof were adduced to clear the ground of those doubts at one time prevalent regarding the originality of the discovery of the modern atomic theory by John Dalton ; now it behoves me to notice the manner in which the new chemical doctrines were received by his contemporaries.

To Dr Thomson of Glasgow must be awarded the honour of first embracing and making known to the world the atomic philosophy. It was during his visit to Manchester in 1804, already mentioned, that

he learned from Dalton's lips his new doctrine, and the experimental evidence on which it reposed. Dr Thomson saw at a glance the immense importance of this theory, and at once cordially adopting it, became and continued, during a long and brilliant scientific career, its most earnest and persevering expounder. He first announced its principles in the third edition of his "System of Chemistry," p. 424, &c., and in January 1808, brought it prominently, with praiseworthy hardihood, before the notice of the Royal Society. In this memoir, on "Oxalic Acid," he showed the existence of two salts of oxalic acid and potash, the oxalate and superoxalate, in the last of which the acid was found to be "very nearly double what is contained in the oxalate." He also proved that there are two oxalates of strontian, and "that the first contains just double the proportion of base contained in the second." These remarkable examples of the law of multiple proportions constituted of themselves, especially at the time when they were made known, invaluable facts in favour of the atomic theory. But Dr Thomson ventured further, at the close of his memoir, to lay down distinctly and fully the doctrines of Dalton, and to give the atomic weights of several bodies—all, it may be observed, in the *gaseous state*—which Dalton had then obtained. "This curious theory," he observes, "which promises to throw an unexpected light on the obscurest parts of chemistry, belongs to Mr Dalton."

At the next succeeding meeting of the Royal Society Dr Wollaston read his remarkable memoir on "Superacid and Subacid Salts." In this he points out the existence of the law of simple multiples in the

subcarbonate and carbonate of potash and soda, in the supersulphate and sulphate of potash, and in the three compounds of potash and oxalic acid—the oxalate, binoxalate, and quadroxalate. In these last the weights of acid combining with a constant quantity of base are represented by the numbers 1, 2, and 4. He regards these facts as "but particular instances of the more general observation of Mr Dalton, that in all cases the simple elements of bodies are disposed to unite atom to atom singly, or if either is in excess, it exceeds by a ratio to be expressed by some simple multiple of the number of its atoms." He adds—"I am further inclined to think that when our views are sufficiently extended to enable us to reason with precision concerning the proportions of elementary atoms, we shall find the arithmetical relation alone will not be sufficient to explain their mutual action, and that we shall be obliged to acquire a geometrical conception of their relative arrangement in all the three dimensions of solid extension."

In a letter dated November 15, 1809, addressed to Dalton by Sir H. Davy, on matters connected with the Royal Institution, he writes:—"I shall be very glad to hear your new views of the atomic system. I think it likely that there is always a regular order of proportions in composition, but I doubt whether we have yet obtained any elements; and I am convinced that there are yet great changes to be made in our existing arrangements." Again, in the year 1811, Sir H. Davy expressed his matured objections to the doctrines of Dalton as follows:—"I shall enter no further at present into an examination of the opinions, results, and conclusions of my learned friend.

I am, however, obliged to dissent from most of them, and to protest against the interpretations that he has been pleased to make of my experiments, and I trust to his judgment and candour for a correction of his views. . . . It is impossible not to admire the ingenuity and talent with which Mr Dalton has arranged, combined, weighed, measured, and figured his atoms ; but it is not, I conceive, on any speculations upon the ultimate particles of matter that the true theory of definite proportions must ultimately rest."

Considering Davy's exalted position as a discoverer in chemistry, his keen vision, fertile imagination, and powers of induction equal to the best men of his epoch, it is much to be regretted that he should have shown such jealousy of his rivals approaching near the throne of science, and apparently so domineering a spirit. In my last volume, when treating of the character of James Losh, Recorder of Newcastle-on-Tyne, I had occasion to point out this marked fault in Davy's scientific temperament. It is more agreeable to note that after a lapse of years Sir Humphrey came round to Dalton's views, and, as mentioned in a previous page, when presenting Dalton with the fifty-guinea prize offered by George IV., spoke in the highest terms of his contemporary.

It may be stated *in limine* that almost all the great chemical writers of the present day concur, without any reservation, in attributing to Dalton the fame of this remarkable discovery. Thus Berzelius affirms—"To Dalton belongs the honour of the discovery of this part of chemical proportions which we name multiple

proportions, and which none of his predecessors had observed."

In the estimation of the same distinguished chemist, writing in 1835, "the atomic hypothesis was afterwards confirmed by numerous experiments; and we may state without exaggeration, that this is one of the greatest steps which chemistry has yet made towards perfection." Mitscherlich thinks "that this hypothesis, like every other, must undergo changes, in proportion as observations are multiplied. It is possible, although highly improbable, that it may be wholly superseded by another; yet the history of science can adduce scarcely any law, and certainly no theory, which has conducted the inquirer to so many discoveries as this hypothesis." Dr Hermann Kopp's opinion coincided with those of Berzelius.

"The extreme simplicity," Sir John Herschel observes, "which characterises the atomic theory, and which is itself an indication, not unequivocal, of its elevated rank in the scale of physical truths, had the effect of causing it to be announced at once by Mr Dalton in its most general terms, on the contemplation of a few instances, without passing through subordinate stages of painful inductive assent by the intermedium of subordinate laws. . . . Instances like this, where great, and indeed immeasurable, steps in our knowledge of nature are made at once, and almost without intellectual effort, are well calculated to raise our hopes of the future progress of science, and by pointing out the simplest and most obvious combinations, as those which are actually found to be most agreeable to the harmony of creation, to hold out the cheering prospect of difficulties diminishing as we advance,

instead of thickening around us in increasing complexity."

Professor Graham states—"But the first foundations of a complete system of equivalents, embracing both simple bodies and their compounds, were laid by Dalton at the same time that he announced his atomic theory." Again—"The laws of combination and the doctrine of equivalents, which have just been considered, are founded upon experimental evidence only, and involve no hypothesis. The most general of these laws were not, however, suggested by observation, but by a theory of the atomic constitution of bodies in which they are included, and which affords a luminous explanation of them. The partial verification which this theory has received in the establishment of these laws adds greatly to its interest, and is a strong argument in favour of its truth."

Dr Faraday, in reply to Dr W. C. Henry's inquiries as to his views, wrote, August 2, 1853: "I do not know that I am unorthodox as respects the atomic hypothesis. *I believe in matter and its atoms* as freely as most people, at least I think so." The subsequent part of his letter showed great reserve of mind as to the existence of "little solid particles" independent of the forces of matter; and apparently his views of the ultimate constitution of matter agreed pretty much with that of the Abbé Boscovich—a little dreamy and uncertain.

Baron Liebig's answer to Dr Henry's application was of a more definite character. He wrote:—

Chemistry received in the atomic theory a fundamental view; which overruled and governed all other theoretical views, to which the ideas of the age respecting chemical forces,

affinity, cohesion referred themselves; it was the bond which bound together all other views. In this lies the extraordinary service which this theory rendered to science—viz., that it supplied a fertile soil for further advancement; a soil which was previously wanting. In the most recent investigations concerning the constitution of organic bases, the alcohols and the acids corresponding to the alcohols, we have seen that the groundwork of the Daltonian theory is equally valid for organic bodies. His main law, that the properties of compounds are dependent on the nature of their elements, and on the mode and way of their position or arrangement, will always maintain a high value.

Professor Roscoe, as President of the Chemical Section of the "British Association for the Advancement of Science" in 1870, after alluding to the views of Sir B. C. Brodie and Dr Odling, with which he mainly agreed, and believing that we must carefully distinguish between fact and theory, went on to say:—

I would remind you that Dalton's discovery of multiple and reciprocal proportions (I use Dr Odling's word), as well as the differences which we now acknowledge in the power of hydrogen-replacement in hydrochloric acid, water, ammonia, and marsh-gas, are *facts*, whilst the explanation upon the assumption of atoms is, as far as chemistry has yet advanced, a *theory*. If, however, the existence of atoms cannot be proved by chemical phenomena, we must remember that the assumption of the atomic theory explains chemical facts as the undulatory theory gives a clear view of the phenomena of light; thus, for instance, one of the most important facts and relations of modern chemistry which it appears difficult, if not impossible, to explain without the assumption of atoms, is that of Isomerism. How otherwise than by a different arrangement of the single constituent particles are we to account for several distinct substances in which the proportions of carbon, hydrogen, and

oxygen are the same? Why, for instance, should 48 parts by weight of carbon, 10 of hydrogen, and 16 of oxygen, united together, be capable of existing as three different chemical substances, unless we presuppose a different statical arrangement of the parts by which these differences in the deportment of the whole are rendered possible?

Professor Cannizzaro of Palermo, now of Rome, delivered the "Faraday Lecture" to the Chemical Society, May 30, 1872. *Nature* of June 20 gives *inter alia* the following as part of the professor's lecture:—

Whilst giving a broad sketch of the progress of modern chemistry, he showed that the atomic theory had become more and more intimately interlaced with the fabric of chemistry, so that it is no longer possible to separate them without rending the tissue, as it were, of the science, and that up to the present time we have been unable to enunciate even the empirical laws of chemical proportion independently of that theory; for those who employ the term equivalent, in the sense that Wollaston did, commit an anachronism. Consequently, in the exposition of the value and use of symbols, formulæ, and chemical equations, not only are we unable to do without the atomic and molecular theory, but it is inconvenient to follow the long and fatiguing path of induction which leads up to it. By one of those bold flights of the human mind we can at once reach the height whence we discern at a glance the relations between facts.

Professor Tyndall, who seconded a vote of thanks to Cannizzaro for his lecture, said:—

The chemist cannot halt at equivalent proportions—he must ask himself whence they arise, and the inevitable answer is some form of the atomic theory. This theory, however, cannot be confined to chemical phenomena. The motions of those atoms and molecules underlie all our explanations of the physical cause of light and heat, and it is already taking up the

field of magnetism and electricity. Consider, for example, the heat of gases, both as regards the motion of translation of the molecules which produce temperature, and the motions of rotation and vibration of their constituent atoms, which, though they do not express themselves as temperature, constitute a portion of the heat.

Dumas, the most distinguished of French chemists ("Leçons sur la Philosophie Chimique," p. 221), calls Dalton "the Nestor of Chemistry;" and *Wurtz* ("Histoire des Doctrines Chimiques," Discour preliminaire, p. xiv.), after describing the relation between combining weights observed by Wengel and Richter, adds :—

Mais l'interpretation théorique faisait encore defaut. Elle découle des travaux d'un savant anglais qui a doté la science de la concéption à la fois la plus profonde et la plus féconde parmi toutes celles qui ont surgi depuis Lavoisier. Au commencement de ce siècle, la chimie etait professée à Manchester par un homme qui joignait à un amour ardent de la science cette noble fierté du savant qui sait prèférer l'independance aux honneurs, et à une vaine popularité la gloire des travaux solides. Ce professeur est Dalton ; son nom est un des plus grands de la chimie.

APPENDIX.

JOHN DALTON'S STATEMENT OF THE CASE IN THE AFFAIR BETWIXT HIS BROTHER AND SELF.

Article 1st. That my father, in apportioning the paternal inheritance to us, has made a vastly great and unusual distinction betwixt my brother and self.

Article 2d. That he would have placed his children upon a more equitable footing, if he had apprehended it was in his power to do so, with reputation to himself.

Article 3d. That it was in his power to dispose of the whole of his property according as he should think best; but from a great deficiency in the knowledge of the law, and from a want of advice suited to the exigencies of his situation at the time he made his will, he has not availed himself of his power.

Article 4th. That upon these considerations, I think myself entitled to something more out of the paternal inheritance than I have yet received.

I shall now state the facts, to the best of my knowledge, in support of these articles.

Facts relating to article 1st.—My father's property, when his verbal will was made, was a real estate, $\frac{5}{8}$ of it freehold, the rest copyhold, let to farm for £41, 10s. p. ann. without the dwelling-house, now let for £2 p. ann. Total, £43, 10s. p. ann.

The neat value, therefore, may be set at £1000. His personal estate was thought to be nearly sufficient to pay his debts. By his will, to which E. and J. Robinson were witnesses, the whole estate, real and personal, was left to brother; but he engaged, as desired, to pay my sister and self each £50 one year after father's decease, and to pay my mother £50 also, or rather an annuity of £6 p. ann. for life: these three fifties, or £150, were expressly mentioned and considered as the value of the copyhold. The freehold was scarcely mentioned. This is the substance of the matter as related by my brother to me at the time (for I was not present): and the two friends, I believe, do not differ materially in their relation. I should, however, except the valuation of the estate at £1000, which is my own, and was not then mentioned I presume. As the estate was not then thought to be chargeable with anything but Aunt Mary's dower out of the copyhold, the rate of brother's part to mine, from this view of things, is as 18 to 1 nearly.

Though this appeared, at the time of father's death, to be a fair estimate, yet from different circumstances the proportion of our shares is much changed. The following, then, is a statement of our shares at father's death, as they have really turned out to be.

Father's real estate, £1000; personal, £73	£1073	Debts	£122
[Debts]	303	Sister's debts*	15
		Mortgage and interest	166
Remr. descended to brother	£770		£303

From this £770, which brother may be said to have received at father's death, we are to deduct the following, in order to get the neat value of his share, viz.: Aunt Mary's dower, 3 years, £40; mother's do., being £8 p. ann. for life, may be estimated at £80. Value of the copyhold, £150, to pay at 1 year, being discounted, is £144. Total, £264. Remains neat to brother, £506. My share, £50, discounted for 1 year, is £48. Ratio $10\frac{1}{2}:1$ nearly.

This, then, is the real proportion of the effects we received immediately from our father.

N.B.—With respect to legacies in a collateral relation, origi-

* *N.B.*—My brother has included these in father's debts: the reason he alleges is that father intended to have paid them on her behalf.

nally out of the same estate, we are pretty much upon a par;—sister dying intestate, we each received £21. Uncle Jona's legacy to my brother is about £15; to myself, £28: the advantage £13 in my favour.

Facts relating to article 2d.—My father expressly told me, about three months before his death, when he was at Kendal, "that Jonathan being provided for, he had only to care for us (meaning sister and self), that he had nothing for us but the tenancy as yet, but that he would be as frugal as might be, in order to accumulate something more for us; that as for the entailed estate he would not touch it."

This is the purport of his words, and I apprehended at the time it was a true statement of the case, and therefore made little, if any, remark upon it to him. Upon this idea the settlement was afterwards made, and J. Robinson says that he asked my father sometime after the settlement was made, whether he continued satisfied with it, and he answered in the affirmative. From the above I am persuaded that my father thought it out of his power, or at least, that he had no business to meddle with the entailed estate. However, as others may not be so, considering I am witness in my own cause, I should therefore direct them to reason upon the following facts, which no one will deny, viz.—

1st, That my father had as much common sense as men at a medium have.

2d, That he had, or might have had, near £1000 value to dispose off by will, from a moderate computation of his effects, as circumstances then appeared to him.

3d, That he left one son, as appeared then, near 18 times as much as the other.

4th, That he was never heard to express the least inclination to cut off the entail, nor to regret at last that he had not cut it off; but, on the contrary, that he was quite easy and satisfied with what he had done.

5th, That there is no person who ever heard him say that he could cut off the entail when he thought fit, or words to this import.

6th, That he was never known to manifest any partiality for

one of his children more than for another, except this be an instance.

Now, I appeal to any one who is acquainted with human nature, whether these facts, together with those that are related to have taken place at the time of the settlement, are better accounted for on the one supposition or the other; on the supposition that he knew very well he could cut off the entail at pleasure without meriting any just censure—or on the supposition that it was not in his power to do so, nor his business to meddle with it.

Facts relating to article 3d.—Every one who is acquainted with the laws of landed property in this country, knows that an entail may be defeated by the tenant in possession. Nothing more is required than to fee a few persons in office, who will, after a sham process, sufficiently guarantee the tenant against the effects of the iniquitous statute. This need not be further insisted upon. With respect to my father's knowledge about these quirks of law, we differ very much: my brother seems to think my father knew as much as the exigencies of his affairs required, and I think quite contrary. It is proper we advance what we have in support of our opinions. I believe father never read a printed page on law in his life. He seems to have had no idea of the difference of an *estate tail* and an *estate for life*, and the whole of his transactions and opinions seem to have been formed on the supposition of the estate being his for life only; I have no doubt that my grandfather designed Uncle Jona to have the estate for life only, and that father, if he survived, should have it fee-simple; however, father, when in possession, finding he had it not fee-simple, concluded the next descent would make it such, and told my brother so, who told it to me not many years ago. Now it is evident that he must have had a very imperfect idea of the tenure of an estate tail, to suppose that simple descent made any difference in the tenure of it. He was equally out of it in the persuasion that neither Aunt Mary D. nor my mother had any claim of dower, as E. and J. Robinson very well know.

I believe he refused J. Sandilands the farm of the stone quarries, from an idea that he had no right to let it. All these things prove him to have been greatly deficient in the knowledge

his affairs required. But, notwithstanding all this, it is said he knew very well he could cut off the entail. I shall now speak more particularly to this point.

When father was informed Uncle Jona demanded the entail deed upon paying the mortgage, he was uneasy; he procured an attested copy of it, and took it to Uncle Greenup. Uncle G. finding the estate *entailed*, and not *for life*, as he had previously apprehended, told him there had been a flagrant mismanagement in the affair, and that as it was, Uncle Jona had the power to cut off the entail at pleasure, and that his interference could be of no service, but might do harm; that his interest was to be quiet and make no noise or opposition about the matter. I relate this to the best of my memory as he told it at his return. Here it rested till Uncle Jonathan's death.

Father hearing Uncle's will, concluded he had availed himself of the power to cut off the entail, and that there was no ground for opposition; accordingly he wrote immediately to brother to come over and settle the matter; but being much agitated with the manner in which Uncle Jona had treated him, and at his open violation of grandfather's known intentions, however he might be sheltered by law in so doing—he thought it proper to advise with J. Robinson of Greysouthen before he sent the letter. J. R. told him the devise of the entailed estate was invalid, as he believed Uncle Jona had not formally cut off the entail; this father added in a postscript, and countermanded his former order. From the conversation betwixt my father and J. R. at this time, and at some other times, the latter has conceived an idea that my father knew a good deal respecting the matter; upon hearing what I have said, and reconsidering the matter, I am inclined to believe he will alter his opinion a little. The subsequent correspondence betwixt my father and Uncle G. did little or nothing more than revive in my father the idea that Uncle Jona might have cut off the entail. This, it is said, is expressed in such clear and strong terms, that father could not avoid understanding it; and yet he misunderstood an expression equally as plain in one letter, which was that aunt Mary would be entitled to dower.

Were we, however, after all to admit that he knew he could

bar the entail; yet his conduct and conversation evidently demonstrate that he considered it as an unjustifiable and reproachful action; this is not much to be wondered at, considering his ignorance in point of law, and the disagreeable idea of the business Uncle Jona's attempt had made. What in Uncle Jona was perhaps censurable, would have been highly meritorious in my father. Is there any one who will say he was sensible of this?

Let any person who is acquainted with the nature of an entail put himself in my father's circumstances, and consider whether the plan he went upon was not the most inconsistent imaginable—a family of three children—a comparatively large portion of freehold—a small portion of copyhold, all in one estate, though under different tenures—to set aside the freehold entirely for one, and to carve in the copyhold for a widow and two children. Would it not have been more consistent and prudential, as soon as his title was fully established, to have cut off the entail immediately, and then he was ready for any occurrence, or else, to avoid expense, have made the next in succession (my brother) enter into some provisional agreement, not to take any advantage of his situation? Father never so much as hinted the least design of this sort, whether it was because he was not careful for his wife and two younger children, or from other causes, I leave to be determined.

E. & J. Robinson, as has been mentioned, were so obliging as to be present at the time of the settlement of my father's affairs, and to advise to the best of their knowledge; whatever my father knew about the entailed estate, I believe they will not hesitate to say they considered it as quite out of his power to devise it, either at that time, or at any other time; and likewise that no dower was claimable on my mother's behalf. Of course they could not but approve the distribution then made. Had they known my mother could claim dower, it seems to me they would have rather advised to increase sister's portion and mine, by dividing the copyhold into two instead of three portions; the debts, too, might have been laid upon the freehold, especially when it is considered that a great portion of them was spent in improvements and other incidental expenses to the freehold. These things might have been done, even if

brother had been disposed to take the utmost advantage of the situation of father's affairs at the time of settlement.

Facts relating to article 4th.—It appears from the nature of the case that I can claim no specific sum, because father never mentioned how he would have distributed his effects amongst us had they been unfettered; but if we may judge from the specimen he has given us in dividing the copyhold, his ideas have not been widely different from those of others who use their reason on such occasions: considering that we stood alike expensive to him in education, and alike circumstanced in every respect, except age, I doubt not he would have placed us upon an equal footing, because the same is reasonable, regard being had to the difference of our ages, by which I mean that we should have been on an equality at equal ages, or that my portion to brother's, taken at any given time, as at his death, would have been as 10 to 13 nearly. To do this at present would take above £200 from him to add to my part; whether disinterested persons who hear all on both sides will judge my right equal to this amount, or something less, or nothing at all; or that I am making all this stir through envy, or some other cause, I know not; they have a right to judge for themselves, and whatever their judgment be I shall not be greatly moved with it. As for myself, when I think about the matter (and who is there would not think about it, considering we were left as 18 to 1, or even as 10 to 1) I am unavoidably led to judge hardly either of my father or brother, on whatever side of the matter I look.

In the one case, supposing it was my father's positive will to leave us so, and that if he had possessed cash instead of land he would have done just the same, I am puzzled to account for his extreme caprice in placing sister and self at such a distance, especially as it was so inconsistent with the general tenor of his character.

In the other case, supposing his want of knowledge in the different points of law to have been the cause of this great distinction, it seems peculiarly uncharitable in a brother to make no allowances for such a circumstance, even if not compellable by law; and if the former were the true case, one would think he could hardly beeasy without making me some amends

for the injury done me by a piece of caprice, which neither he nor any one else ever pretended to account for.

ADDENDA.—Having given the above statement into my brother's hand, he drew up his likewise and gave it to me to peruse. I have nothing to remark thereon till he comes to state our respective receipts, where he calculates the value of the freehold upon the supposition of an annuity for life: which calculation I think merits no notice, because he allows that by paying £20 the value will be increased £300, and because he would not part with the estate for the sum he has put down.

Also he places the fine on the tenancy amongst the encumbrances: I supposed the estate would bring £1000, though it might cost the purchaser £1000 and the fine: in other respects we differ no otherwise in stating his receipts than that I have taken round numbers. With respect to my receipts he has put down £20 that I have on the part of my mother, but do not know whether I can call it my own; it is hers if she demand it: however this may be, if I be placed anything near on an equitable footing with him, I shall give it up to her.

He has put our legacies from uncle and sister into the account; this appears to me unfair, because these were contingencies which my father could not foresee, and therefore could not influence his conduct to us; and besides, if we had been equal before, these would not have much disturbed the equality; we ought then to ascertain the proportions which we have received from him, and which are nearly as I have stated above.

JOHN DALTON.

KENDAL, 12 *mo.* 1792.

For the arbitrators in the above-mentioned case.

LIST OF DR DALTON'S PAPERS,

READ BEFORE THE MEMBERS OF THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

1. October 31, 1794. Extraordinary Facts relating to the Vision of Colours, with Observations.

2. November 27, 1795. On the Colour of the Sky, and the Relation between Solar Light and that derived from Combustion; with Observations on Mr Delaval's Theory of Colours.

3. April 7, 1798. Essay on the Mind, its Ideas, and Affections; with an Application of Principles to explain the Economy of Language.

4. March 1, 1799. A Paper containing Experiments and Observations, to determine whether the quantity of Rain and Dew is equal to the quantity of Water carried off by the Rivers and raised by Evaporation; with an Inquiry into the Origin of Springs.

5. April 12, 1799. Experiments and Observations on the Power which Fluids possess of conducting Heat; with Reference to Count Rumford's Seventh Essay.

6. June 7, 1799. On the Colour of the Sky, and the Relation betwixt Solar Light and that derived from Combustion; with Observations on Mr Delaval's Theory.

7. April 18, 1800. Experimental Essays, to determine the Expansion of Gases by Heat, and the *maximum* of Steam or Aqueous Vapour, which any Gas of a given Temperature can admit of; with

Observations on the Common and Improved Steam Engines.

8. June 27, 1800. On the Heat and Cold produced by the Mechanical Condensation and Rarefaction of air.

9. October 17, 1800. Philological Inquiry into the Use and Signification of the Auxiliary Verbs and Participles of the English Language.

10. December 12, 1800. Review of Dr Herschel's Experiments on the *Radiant* Heat, and the Reflectibility and Refrangibility of Light.

11. July 31, 1801. Read Part 1st of Mr Dalton's Paper on the constitution of Mixed Gases, &c.

12. October 2, 1801. Read Part 2d of Mr Dalton's Paper on the Force of Steam, &c.

13. October 16, 1801. Read Part 3d of Mr Dalton's Paper on Evaporation, &c.

14. January 22, 1802. On the General Causes, Force, and Velocity of Winds; with Remarks on the Seasons most liable to High Winds.

15. October 29, 1802. On the Proportion of the several Gases or Elastic Fluids, constituting the Atmosphere; with an Inquiry into the Circumstances which distinguish the *Chymical* and *Mechanical* Absorption of Gases by Liquids.

16. January 14, 1803. On the Spontaneous Intercourse of different Elastic Fluids, in confined circumstances.

17. October 7, 1803. On the Absorption of Gases by Water.

18. November 4, 1803. On the Law of Expansion of Elastic Fluids, Liquids, and Vapours.

19. February 24, 1804. A Review and Illustration

of some Principles in Mr Dalton's course of Lectures on Natural Philosophy, at the Royal Institution, in January 1804.

20. August 3, 1804. On the Elements of Chemical Philosophy.

21. October 5, 1804. On Heat.

22. November 30, 1804. Review of Dr Hope's Paper "On the Contraction of Water by Heat."

23. September 2, 1805. Remarks on Mr Gough's two Essays on Mixed Gases, and on Mr Schmidt's "On Moist Air."

24. March 7, 1806. On Respiration and Animal Heat.

25. February 6, 1807. On the Constitution and Properties of Sulphuric Acid.

26. October 2, 1807. On Heat.

27. October 16, 1807. On the Expansion of Bodies by Heat.

28. January 22, 1808. On the Specific Heat of Bodies.

29. March 18, 1808. On the Specific Heat of Gaseous Bodies.

30. December 2, 1808. On the Measure of Mechanical Force.

31. December 16, 1808. On Respiration.

32. March 10, 1809. On Evaporation.

33. April 7, 1809. On the Compounds of Sulphur.

34. November 3, 1809. On Muriatic Acid.

35. December 1, 1809. On Sulphuric Acid.

36. March 9, 1810. On Fog.

37. November 16, 1810. Appendix to his Remark on Respiration and Animal Heat.

38. December 28, 1810. On Hygrometry.

39. April 3, 1812. On Meteorology.

40. April 17, 1812. Meteorology continued.

41. October 2, 1812. On the Oxy-muriate of Lime.

42. January 8, 1813. Experiments on Phosphoric Acid, and the Phosphates.

43. March 5, 1813. Experiments and Observations on the different compounds of Carbonic Acid and Ammonia.

44. October 11, 1813. On the Combinations of Gold.

45. October 15, 1813. Continuation of the paper on the Combinations of Gold.

46. November 12, 1813. The Combinations of Platina.

47. December 10, 1813. On the Cause of Chemical Proportion, being remarks on a paper by Berzelius.

48. January 7, 1814. Experiments on certain Frigorific Mixtures.

49. March 18, 1814. Remarks tending to facilitate the Analysis of Spring and Mineral Waters.

50. October 7, 1814. On Metallic Oxides.

51. December 2, 1814. On Metallic Oxides (continued).

52. January 27, 1815. Critical remarks on some modern Chemical Phrases.

53. November 17, 1815. Remarks on Saussure's Essay on the Absorption of Gases by Liquids.

54. October 4, 1816. On the Chemical Compounds of Azote and Oxygen.

55. December 13, 1816. An Appendix to the Essay on Chemical Compounds of Azote and Oxygen.

56. October 3, 1817. On Phosphurets, or the

Combinations of Phosphorus, with Earths, Alkalies, Metals, &c.

57. November 21, 1817. Observations on Oxides and Sulphurets.

58. November 13, 1818. Observations on the Quantity of Rain during the last twenty-five years; with Remarks on the Theory of Rain.

59. December 11, 1818. Summary of Observations on the Barometer and Thermometer made at Manchester for the last twenty-five years.

60. January 8, 1819. Experiments on the Force of the Vapour of Ether, to show the fallacy of some of Dr Ure's Statements just published in the Philosophical Transactions.

61. April 16, 1819. On Sulphuric Ether.

62. October 15, 1819. On Alloys, particularly those of Copper and Zinc, and Copper and Tin.

63. November 12, 1819. On Amalgams, and other Metallic Alloys.

64. December 10, 1819. A Chemical Analysis of the Mineral Waters of Buxton.

65. October 6, 1820. On Oil, and the Gases obtained from it by Heat.

66. December 1, 1820. On Alum.

67. January 26, 1821. On Meteorology, or Observations on the Weather for the years 1819 and 1820 in Manchester.

68. February 9, 1821. Observations on Meteorology, particularly with regard to the Dew Point, &c., or quantity of Vapour in the Air.

69. October 5, 1821. Some Observations on the Salts and Sulphurets of Iron.

70. November 30, 1821. On the Effects of Con-

tinued Electrification on Compound and Mixed Gases.

71. December 13, 1822. On the Saline Impregnations of the Rain which fell during the late storm, viz., December 5, 1822.

72. March 21, 1823. Appendix to an Essay on Salt Rain (read December 13, 1822), with additional Observations on the succeeding Storms of Wind and Rain.

73. November 14, 1823. On the Nature and Properties of Indigo; with directions for the valuation of different samples.

74. December 26, 1823. On various Alloys of Tin, Zinc, Lead, Bismuth, Antimony, &c.

75. October 15, 1824. On Associations for the Promotion of the Physical Sciences, Literature, and the Arts.

76. November 12, 1824. An Account of some Experiments to determine the Light and Heat given out by the Combustion of different Gases.

77. April 15, 1825. Results of Meteorological Observations at Manchester, for thirty-one years; with Remarks upon them.

78. December 30, 1825. On the Constitution of the Atmosphere.

79. October 6, 1826. On the Height of the Aurora Borealis above the Surface of the Earth, particularly the one seen on the 29th March 1826.

80. November 4, 1826. An Appendix to a paper read on October 6, on the Height of the Aurora Borealis above the Surface of the Earth.

81. November 26, 1827. An Historical Sketch of the Society's Library; with an account of its present state.

82. December 28, 1827. Observations, chiefly Chemical, on the nature of the Rock Strata in Manchester and its vicinity.

83. October 17, 1828. Summary of the Rain, &c., at Geneva and at the elevated station of St Bernard, for a series of years, from the "Bibliotheque Universelle" for March 1828; with observations on the same.

84. January 8, 1830. Physiological Investigations deduced from the Mechanical Effects arising from Atmospherical Pressure on the Animal Frame.

85. January 22, 1830. Remarks on a Statement of the Amount of Rain fallen at different places on the line of the Rochdale Canal.

86. March 5, 1830. On the Quantity of Food taken by a person in health, compared with the Quantity of the different Secretions during the same period; with Chemical Remarks on the several Articles.

87. October 15, 1830. Chemical Observations on certain Atomic Weights, as adopted by different Authors; with some Remarks on the Notation of Berzelius.

88. October 29, 1830. Observations on the Causes of Colouring Matter.

89. November 23, 1830. Chemical Observations on certain Atomic Weights, as adopted by different Authors; with Remarks on the Notation of Berzelius.

90. January 21, 1831. Meteorological Observations for a period of thirty-seven years; with Theoretical Remarks.

91. February 18, 1831. On the Quantity of Oxygen in Atmospheric Air.

92. December 2, 1831. On the Proportion of Oxygen Gas in the Atmosphere.

93. January 13, 1832. A Summary of Meteorological Observations for 1831, made in Manchester and the Vicinity.

94. January 11, 1833. Mr Dalton's Remarks on the Meteorology of the last year.

95. March 8, 1833. Observations on the Anomalous Vision of Colours.

96. November 1, 1833. A Description of an *imaginary* Aurora Borealis in the North of England.

97. February 7, 1834. An Account of Meteorological Observations at Manchester and other places in the year 1833.

98. March 7, 1834. Some Remarks on Clouds; their Nature, Height, &c.

99. October 17, 1834. Observations on certain Liquids obtained from Caoutchouc by Distillation.

100. December 26, 1834. Observations on the various accounts of the Luminous Arch or Meteor accompanying the Aurora Borealis of November 3, 1834.

101. February 20, 1835. Account of Meteorological Observations made in Manchester and other places in 1834.

102. October 2, 1835. Read a paper by Mr Dalton. (Subject not named in the Journal.)

103. February 15, 1836. An Account of Meteorological Observations made in Manchester and other places in 1835.

104. October 21, 1836. Sequel to an Essay on the Constitution of the Atmosphere; read to the Society in the year 1825. Part I.

105. November 4, 1836. Second part of a paper

entitled "Sequel to an Essay on the Constitution of the Atmosphere."

106. October 2, 1838. On Arseniates and Phosphates.

107. February 5, 1839. Some Account of Meteorological Observations made in Manchester in the years 1836–38.

108. October 1, 1839. On the Ammoniaco-Magnesian Phosphate, as it was formerly called; or the Tribasic Phosphates of Magnesia and Ammonia, as Professor Graham has called it. And on the Phosphate of Soda and Ammonia, or Microscopic Salt, as it was formerly called; and now Tribasic Phosphate of Soda and Ammonia and Water, of Professor Graham.

109. March 31, 1840. On the Quantity of Acids, Bases, and Water in the different varieties of Salts; with a New Method of Measuring the Water of Crystallisation of Water.

110. April 28, 1840. Some Account of Meteorological Observations made in Manchester in the year 1839.

111. October 6, 1840. Continuation of a paper on the Quantity of Acids, Bases, and Water in the different varieties of Salts.

112. January 12, 1841. Meteorological Observations made in Manchester and the neighbourhood during the year 1840, or previously.

113. March 9, 1841. On a New and Easy Method of Analysing Sugar.

114. October 5, 1841. On a Citric Acid, the Oxalic Acid, the Acetic Acid, and Tartaric Acid.

115. January 10, 1843. Meteorological Observations at Manchester, made in the year 1842.

116. April 16, 1844. On the Fall of Rain, &c., in Manchester, during a period of fifty years.

Some of these were embodied in other works or printed elsewhere.

In Nicholson's Journal.

New Theory of the Constitution of Mixed Gases elucidated, Vol. iii., p. 26. November 18, 1802.

Letter from Mr Dalton, containing Observations concerning the Determination of Zero of Heat, the Thermometrical Gradation, and the Law by which Dense or Non-elastic Fluids expand by Heat, Vol. v., p. 34. April 20, 1803.

Correction of a mistake in Dr Curwen's Essay on the State of Vapour in the Atmosphere, Vol. vi., p. 118. August 22, 1803.

On the supposed Chemical Affinity of the Elements of Common Air; with Remarks on Dr Thomson's observations on that subject, Vol. viii., p. 145. June 16, 1804.

Observations on Mr Gough's Strictures on the Doctrine of Mixed Gases, &c., Vol. ix., p. 89. September 8, 1804.

Facts tending to Decide the Question at what Point of Temperature Water possesses the greatest Density, Vol. x., p. 93. January 10, 1804.

Extract of a Letter from Mr J. Dalton: On a remarkable Aurora Borealis, Vol. x., p. 303. March 12, 1805.

Remarks on Count Rumford's Experiments relating to the Maximum Density of Water, Vol. xii., p. 28. August 17, 1805.

Investigation of the Temperature at which Water is of the greatest Density, from the experiments of Dr Hope, on the Contraction of Water by Heat at low temperatures, Vol xiii., p. 377. April 14, 1806. And Vol. xiv., p. 128. May 1806.

Inquiries concerning the Signification of the word Particle, as used by modern chemical writers, as well as concerning some other terms and phrases, Vol. xxviii., p. 81. December 19, 1811.

Remarks on Potassium, Sodium, &c., Vol. xxix., p. 129. May 11, 1811.

Observations on Dr Bostock's Review of the Atomic Principles of Chemistry, Vol. xxix., p. 143. May 15, 1811.

In Thompson's "Annals of Philosophy."

Further Observations and Experiments on the Combinations of Oxymuriatic Acid with Lime, Vol. ii., p. 6. 1813.

Remarks on the Essay of Dr Berzelius, on the Cause of Chemical Proportion. December 24, 1813. Vol. iii., p. 174. 1814.

Vindication of the Theory of the Absorption of Gases by Water against the conclusions of Saussure, Vol. vii., p. 215. 1816.

On the Chemical Compounds of Azote and Oxygen, and on Ammonia, Vols. ix., p. 186, and x., pp. 38 and 83. 1817.

On Phosphuretted Hydrogen, Vol. xi., p. 7. 1818.

On the Combustion of Alcohol, by the lamp without flame, Vol. xii. p. 245. 1818.

On the Vis Viva, Vol. xii., p. 444. 1818.

In Phillips' "Annals of Philosophy."

On the Analysis of Atmospheric Air by Hydrogen, Vol. x., N. S.

In the "Philosophical Transactions."

On the Constitution of the Atmosphere. 1826.

On the Height of the Aurora Borealis. 1828.

Sequel to an Essay on the Constitution of the Atmosphere; with some Account of the Sulphurets of Lime. 1837.

In the "Annales de Chimie."

Sur l'Hydrogène Phosphuré (Extract of a letter addressed to the Royal Academy of Sciences), Vol. vii. 1817.

In a Separate Form. 1840.

Essay on the Phosphates and Arseniates.

On Microcosmic Salt.

On the mixture of Sulphate of Magnesia and the Biphosphate of Soda.

Essay on the Quantity of Acids, Bases, and Water in the different varieties of Salts; with a New Method of Measuring the Water of Crystallisation as well as the Acids and Bases.

On a New and Easy Method of Analysing Sugar.

"GRAMMAR," 1801. His "METEOROLOGY," 1793.

"NEW SYSTEM OF CHEMISTRY," Part I., 1808; Part II. 1810, Vol. ii., Part I. 1827.

A new edition of Vol. i., Part I., appeared in 1841, and a new edition of his METEOROLOGY in 1834.